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Valuation in the energy sector: Fundamentals or bubbles?*

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ABSTRACT

We analyze valuation in the energy sector using the present value model as a framework. Using a panel sample of sector indexes and firms from Canada, Japan, the United Kingdom, and the United States, we find only weak evidence that prices follow the fundamentals for oil explorers and producers subsector. A variance decomposition analysis shows that mostly shocks in discount rates, seen as investor sentiment changes and not changes in cash flows, affect valuation. Further tests detect explosive bubbles on the exploration and production sector in the United Kingdom and in integrated subsector for Canada in the late 1990's and around 2005 that are driven by high prices. Overall, results cast doubt on the role of fundamentals and favor more the importance of bubbles in driving valuation.

JEL classification: G15; Q43

Keywords: Bubbles; Cointegration with breaks; Dividend yield; Fundamental value; Oil industry; Present value; Panel cointegration; Panel unit root tests.

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I. Introduction

The link of equity prices with the fundamentals is an issue debated in the literature as influential work shows that prices change too much regarding fundamentals (e.g. Shiller, 1981, 2014, 2015). This paper looks at this issue in the energy sector using the present value model as the basic framework of analysis.[1]

Despite its acknowledged economic and strategic importance, the analysis of drivers of valuation has been overlooked in the energy sector. This is of special interest in the oil and gas sector since research shows strong links between companies' returns and stock market and oil returns, which could challenge the theoretical relationship, and alternatively explain market prices (see e.g. Sadorsky, 2001; Park and Ratti, 2008; Ramos and Veiga, 2011). Thus, we investigate whether energy-sector valuation is linked to the fundamentals but also to the stock market or to oil values. In addition, the research on valuation goes hand in hand with research on so-called "bubbles".[2] The energy sector might be impacted not only by stock-market bubbles but also by oil-price bubbles (see Noguera, 2013; Sharma and Escobari, 2018). Therefore, examining the valuation of the energy sector and the role of fundamentals is of interest for multiple economic agents.

Understanding changes in market prices has been a core issue in the financial economics literature. In an influential paper, Shiller (1981) argues that volatility in stock prices is too excessive to be justified by changes in market fundamentals alone. Subsequent works by Campbell and Shiller (1987) and Campbell and Shiller (1988a,b) develop a framework to test the present value model using stationarity tests and cointegration methods. Aimed at capturing the economic relationship between prices and dividends, these tests have been used to study stock market data in the aggregate, but evidence for their validity has been weak (e.g. Zhong et al., 2003).

[1] The energy sector has been crucial in supporting the rapid worldwide economic development of recent decades (e.g. Soytas and Sari, 2003; Lee, 2005; Narayan and Smyth, 2008; Ozturk, 2010; Payne, 2010a,b; Narayan and Popp, 2012). The projections also show that fossil fuels such oil, coal, and natural gas will continue to dominate (see BP, 2019), mainly driven by the development of emerging market countries (see Olivier et al., 2016).

[2] As Shiller (2014) emphasizes, there is a not a clear definition of "bubble". Commonly, price deviations from fundamentals are interpreted as supporting evidence of "rational" bubbles (see e.g. Diba and Grossman, 1988; Sarno and Taylor, 1999).

Subsequent research makes use of advances in panel methods to test the present value model in sector and firm data. Nasseh and Strauss (2004) use US stock market data and Goddard et al. (2008) use UK firm-level data to find evidence supporting the present value model. However, using data at the sector level, McMillan (2010) finds limited support for the present value model. Cerqueti and Costantini (2011) advance the explanation that the overejection of the present value could be due to not acknowledging breaks in time series. They refine the analysis by accounting for breaks, and find strong evidence in favor of the bubbles phenomena for international stock market indexes and no link of prices with the fundamentals.

Studies with different methodologies highlight the mean reversion nature of valuation ratios. Coakley and Fuertes (2006) conclude that while market sentiment plays an important transitory role, valuation ratios revert to the mean and prices reflect fundamentals in the long run. Velinov and Chen (2015) find that after the 2008 financial crisis, stock prices had a self-correction towards their fundamental values in G7 countries.

This work provides a two-tiered analysis. Valuation of the energy sector is studied both both the subsector and firm level. Although the majority of studies use aggregated data, works such as Vuolteenaho (2002) and Jung and Shiller (2005) argue that the present value model is more likely to be found at firm level. However, one could also argue that individual firm prices are prone to more noise deviating from fundamentals.

Second, we use panel data methods, which are generally considered to be a means of generating more powerful tests with respect to the univariate counterpart. However, cross-sectional analysis raises the problem of cross-sectional dependence due to the potential interconnection among countries and firms under investigation. To address this issue, we use tests of unit roots that take into account the existence of structural breaks and cross-dependence among countries and firms such as in the work of Carrion-i Silvestre et al. (2009).

We then investigate the existence of cointegration relationships between prices and dividends in sectors, but also in firms, with the panel cointegration tests proposed by Banerjee and Carrion-i Silvestre (2015). These tests allow for cross-section dependence and the factors that are generating this cross-section dependence can be integrated processes. Furthermore, they also allow for breaks in the trends generating the processes.

To test the model, we use oil and natural gas sector indexes from the following countries: Canada, Japan, the United Kingdom (UK), and the United States (US). We analyse two subsectors, the exploration and production subsector and the integrated subsector. Firms in the exploration and production subsector are in the initial part of the oil value chain where firms look for new oil resources and bring them to the surface. Integrated companies participate in every step of the oil or gas business chain, including discovering, extracting, producing, refining, and distributing oil and natural gas. We also use data for firms in these subsectors.

Following the approach developed in Campbell and Shiller (1987, 1988b,a), we apply stationarity tests to the log of the dividend yield. If the dividend yield is stationary, the relationship between prices and dividends is stable, giving empirical support for the economic link between prices and fundamentals. We find that the dividend yield is stationary only for the exploration and production subsector, but we do not find evidence of stationarity for the panel of firms.

Then we test for cointegration between prices and dividends. The existence of a long-term relationship between prices and dividends supports the present value model. We test for cointegration relationships among the variables with Banerjee and Carrion-i Silvestre (2015)'s test, taking breaks into account. We find that prices and dividends are cointegrated for the exploration and production subsector both for sector and firm panel data when we consider the existence of one break in the level of the series and in the cointegration vector. However, this finding disappears when we consider the existence of two breaks in the level of the series and in the cointegration vector, casting doubt on the existence of cointegration between prices and dividends.

We proceed to test alternative hypotheses that the overall stock market valuation and the price of oil drive valuation in the energy sector. The results do not support the hypothesis that prices are cointegrated, with the oil price at the sector level and at the firm level. But there is some evidence of cointegration with the market when we consider the existence of two breaks on the time series, in particular, on the level of the series and on the cointegration vector.

We complement our analysis by decomposing the variability in the valuation ratios into two components: cash flows and the discount rate, along the lines of the (Campbell and Shiller, 1988b) framework. This analysis allows understanding whether variation in the dividend yield ratio comes from changes on cash flow or discount rates. The first suggests rational behavior, while the second can be interpreted as market sentiment. The results show that changes in the dividend yield are driven more by news on discount rates than by news on cash flows, which is in line with literature reporting that stock index returns change mostly with discount rate news (see e.g. Campbell and Ammer, 1993; Ammer and Mei, 1996; Van Binsbergen and Koijen, 2010).[3]

The weak evidence of a stable relationship between prices and dividends (stationarity and cointegration tests) as well as the influence of market sentiment favors a hypothesis of bubbles in valuations in the sector, which we test more formally using the supreme of recursively determined ADF t-statistics (SADF) and the generalilized SADF (GADF) test proposed by Phillips and Yu (2011) and Phillips et al. (2015), respectively. The power of the GSADF test is greater when there are multiple periods of exuberance and collapse than that of the SADF.[4] Instead, the GSADF evaluates several subsamples of the data and uses different window widths. First, we test the bubble hypothesis for the price-dividend ratio. The results are supportive of bubbles for the exploration and producers subsector in the United Kingdom and the United States (although weaker evidence for the latter), and in the integrated sector for Canada. The graphical dating highlights the bubble periods in valuation in late 1990's and 2005. We complement the analysis testing explosive behavior on prices that show that the high valuation ratio period overlaps with periods of high prices.

In the robustness analysis, we repeat the analysis at the individual level (not in panel), and

[3]Cochrane (2011) in his AFA presidential address makes the prominent point for discount rates being the sole driver for price-dividend variation.

[4]The SADF test is quite effective when there is a single bubble in the sample. However, if there are multiple bubble episodes in the sample period under analysis it looses power. In fact, the SADF can suffer from inconsistency and fail to detect bubbles. To overcome this shortcoming, Phillips et al. (2015) propose the GSADF test.

find that valuation in the exploration and production sector in the U.S. seems to follow the present value model, as well as some isolated cases in the firm dataset.

The paper is organized as follow. Section II presents the theoretical and empirical framework. Section III describes the data. Sections IV and V presents the results of our tests, and section IX summarises and discusses the results.

II. The Theoretical and Empirical Framework

A. The Present Value Model

The present-value model, a cornerstone of finance theory that is presented in all finance textbooks (e.g. Damodaran et al., 2007; Damodaran, 2012), is the framework we use to analyze changes. We will follow Campbell and Shiller (1988a,b), who have developed a well-known log-linear approximation to test empirically the model.[5]

Campbell and Shiller (1988b) derive a log-linear dividend-price ratio model that allows for the role of a time-varying real discount rate, that is:

$$p_t = \frac{k}{1-\rho} + E_t\left[(1-\rho)\sum_{i=0}^{\propto}\rho^i d_{t+1+i} - \sum_{i=0}^{\propto}\rho^i r_{t+1+i}\right], \tag{1}$$

where the lower case letters p, d and r denote the logarithms of prices, dividends and the discount rate, respectively. The symbols ρ and k denote linearization parameters, that is, $\rho = 1/[\exp(d-p)]$ and $k = -\log(\rho) - (1-\rho)\log(1/\rho - 1)$. We can re-write Equation 1 in terms of the log dividend yield as

$$d_t - p_t = \frac{k}{1-\rho} + E_t\left[\sum_{i=0}^{\propto}\rho^i(-\Delta d_{t+1+i} + r_{t+1+i})\right]. \tag{2}$$

Equation 2 states that if dividends are expected to grow, then current prices will be higher and the dividend yield will be lower.

[5]A more detailed explanation of the model is in the Appendix.

The next two subsections describe the approach used to test the present value model, which consists of two steps. In the first step, we test the stationarity of the dividend yield. In the second step, we test the existence of a cointegration relationship between real stock prices and dividends. If both stock prices and dividends are both cointegrated processes of order one, together with the assumption of a time-invariant discount rate, then the present value model predicts that there is a long-term equilibrium (cointegration) relationship between real stock prices and dividends (see Campbell and Shiller, 1987; Campbell, Lo, and MacKinlay, 1997).

B. Stationarity Tests

Assuming a time-varying discount rate, the logarithm of the dividend yield (i.e., the difference between the logarithm of the dividend and stock price) follows a stationary process if the present value model holds (e.g. Campbell and Shiller, 1988a,b; Diba and Grossman, 1988). Therefore, we start by testing its stationarity.

B.1. Econometric Framework

We use the panel unit root statistics proposed by Carrion-i Silvestre et al. (2009) to empirically test the stationary of the logarithm of the dividend yield d. The null hypothesis of the test is that d has a unit root (for all countries and firms), and includes the possibility of structural breaks affecting the mean and the trend of the series. The rejection of the null hypothesis means that some series of d are integrated of order zero, that is, they are stationary, with possible structural breaks. If this is the case, it is not compatible with the hypothesis of bubble episodes in the sample (see Diba and Grossman, 1988).

Unit root tests The panel unit root statistics proposed by Bai and Carrion-I-Silvestre (2009) combine the Modified Sargan-Bhargava (MSB) tests for individual series taking into account the presence of structural breaks and cross-dependence in the framework of the common factors model of Bai and Ng (2004). Bai and Carrion-I-Silvestre (2009) point out that failing to consider the presence of structural breaks may lead to misleading conclusions about the order of integration of a time series. In other words, they argue that a stationary time series that evolves around a broken trend might be regarded as a non-stationary process if the unit root test ignores the presence of structural breaks.

Bai and Carrion-I-Silvestre (2009) show that when the structural breaks affect the slope of the series, the procedure proposed by Bai and Ng (2004) is not valid. To overcome this drawback, they propose an iterative estimation procedure that allows unknown breaks in the deterministic components. Their procedure is based on the general panel data model

$$X_{i,t} = D_{i,t} + \boldsymbol{F_t'}\boldsymbol{\pi_i} + e_{i,t} \tag{3}$$

$$(1 - L)\boldsymbol{F_t} = C(L)u_t$$

$$(1 - \rho_i L)e_{i,t} = H_i(L)\epsilon_{i,t},$$

where $t = 1, \cdots, T$ and $i = 1, \cdots, N$, $C(L) = \sum_{j=0}^{\infty} C_j L^j$, $H_i(L) = \sum_{j=0}^{\infty} H_{i,j} L^j$, L is the lag operator and ρ_i is the autoregressive parameter that can be different for each i. The component $D_{i,t}$ includes the deterministic part of the model, $\boldsymbol{F_t}$ is an $(r \times 1)$ vector that accounts for the common factors of the panel, $u_t \sim i.i.d.(0, \sum_u)$, and $e_{i,t}$ is the idiosyncratic disturbance term. For each i, $\epsilon_{i,t} \sim i.i.d.(0, \sum_{\epsilon_i})$.[6] Moreover, $\boldsymbol{F_t}$ can be I(0), I(1), or a combination of both, depending on the rank of $C(1)$. If $C(1) = 0$, then $\boldsymbol{F_t}$ is I(0). If $C(1)$ is of full rank, then each component of $\boldsymbol{F_t}$ is I(1). On the other hand, if $C(1) \neq 0$ but not full rank, some components of $\boldsymbol{F_t}$ are I(1) and some are I(0). Regarding the deterministic component $D_{i,t}$ in Equation 3, Bai

[6]See Bai and Carrion-I-Silvestre (2009) for further details on the assumptions regarding the model.

and Carrion-I-Silvestre (2009) consider two models

$$\begin{aligned}\textbf{Model} \quad \textbf{1}: \qquad D_{i,t} =& \mu_i + \sum_{j=1}^{l_i} \theta_{i,j} DU_{i,j,t} \\ \textbf{Model} \quad \textbf{2}: \qquad D_{i,t} =& \mu_i + \beta_i t + \sum_{j=1}^{l_i} \theta_{i,j} DU_{i,j,t} + \sum_{k=1}^{m_i} \gamma_{i,k} DT_{i,k,t},\end{aligned}$$

where l_i stands for structural breaks affecting the mean and m_i denotes structural breaks affecting the trend of the time series. Notice that both models assume that the structural breaks are heterogeneous across individuals and l_i is not necessarily equal to m_i. The dummy variables are defined as $DU_{i,j,t} = 1$ for $t > T^i_{a,j}$ and 0 otherwise, and $DT_{i,k,t} = (t - T^i_{b,k})$ for $t > T^i_{b,k}$ and 0 otherwise, where $T^i_{a,j}$ and $T^i_{b,k}$ denote the j-th and k-th the breaks occurring in the level and the trend, respectively, for the i-th individual, $j = 1, \cdots, l_i$ and $k = 1, \cdots, m_i$.

Bai and Carrion-I-Silvestre (2009) use two approaches for combining individual statistics. The first approach consists of averaging the individual statistics, that is,

$$Z = \sqrt{N} \frac{\overline{MSB(\lambda)} - \overline{\xi}}{\overline{\varsigma}} \to N(0,1),$$

with $\overline{MSB(\lambda)} = N^{-1} \sum_{i=1}^{N} MSB_i(\lambda_i), \overline{\xi} = N^{-1} \sum_{i=1}^{N} \xi_i$ and $\overline{\varsigma}^2 = N^{-1} \sum_{i=1}^{N} \varsigma_i^2$. ξ_i and ς_i^2 denote the mean and the variance of the individual $MSB_i(\lambda_i)$ statistics, respectively, and $\lambda_i = T_b i/T$ is the break fraction parameter (see Carrion-i Silvestre et al., 2009, for details on the test procedure).

To remove the break fraction parameter from the limiting distribution when considering Model 2, Carrion-i Silvestre et al. (2009) propose a new test also based on the simplified MSB statistics which is defined as

$$Z^* = \sqrt{N} \overline{\frac{MSB^*(\lambda) - \overline{\xi^*}}{\overline{\varsigma^*}}} \to N(0,1),$$

where $\overline{MSB^*(\lambda)} = N^{-1} \sum_{i=1}^{N} MSB_i^*(\lambda_i), \overline{\xi^*} = N^{-1} \sum_{i=1}^{N} \xi_i^*$ and $\overline{\varsigma^*}^2 = N^{-1} \sum_{i=1}^{N} \varsigma_i^{*2}$. $\overline{\xi_i^*}$ and $\overline{\varsigma_i^{*2}}$

denote the mean and the variance of the individual $MSB_i^*(\lambda_i)$ statistics, respectively.[7]

The second approach is based on the procedure provided by Maddala and Wu (1999) and Choi (2001) which pools the p-values associated with the individual statistics, that is

$$P_m = \frac{-2\sum_{i=1}^{N} ln\, p_i - 2N}{\sqrt{4N}} \rightarrow N(0,1),$$

where p_i is the p-value of the individual statistic with $i = 1, \cdots, N$. Bai and Carrion-I-Silvestre (2009) also provide a corresponding P_m^* statistic, which is computed using the p-values of the simplified MSB statistic.

B.2. Cointegration Tests

As explained before, the present value model predicts a long-term equilibrium relationship between real stock prices and dividends. In order to test this long-run relationship, we use the test proposed by Banerjee and Carrion-i Silvestre (2015), whose null hypothesis is the existence of no–cointegration in the panel. The test allows for both structural breaks and cross-sectional dependence. The design of the test considers the following specification that nests several models:

$$y_{i,t} = D_{i,t} + x'_{i,t}\delta_{i,t} + u_{it}, \tag{4}$$

where $Y_{i,t} = (y_{i,t}, x'_{i,t})'$ is a $(m \times 1)$ vector whose elements are $I(1)$ individually.

$$u_{i,t} = F'_t\pi_i + e_{it}, \tag{5}$$

$$(I - L)F_t = C(L)w_t, \tag{6}$$

$$(1 - \rho_i L)e_{i,t} = H_i(L)\epsilon_{i,t}, \tag{7}$$

$$x_{i,t} = \kappa + x_{i,t-1} + G'_t\zeta_i + \Xi_i(L)v_{i,t}, \tag{8}$$

$$G_t = \Gamma(L)\varpi_t, \tag{9}$$

[7]See Bai and Carrion-I-Silvestre (2009) for the details on the individual simplified MSB statistics.

with $i = 1, \cdots, N$, $t = 1, \cdots, T$, $C(L) = \sum_{j=0}^{\infty} C_j L^j$, $H_i(L) = \sum_{j=0}^{\infty} h_{i,j} L^j$, $\Xi_i(L) = \sum_{j=0}^{\infty} \Xi_{i,j} L^j$ and $\Gamma(L) = \sum_{j=0}^{\infty} \Gamma_j L^j$. Furthermore, the deterministic term $D_{i,t}$ is given by

$$D_{i,t} = \mu_i + \beta_i t + \sum_{j=1}^{m_i} \theta_{i,j} DU_{i,j,t} + \sum_{j=1}^{m_i} \gamma_{i,j} DT_{i,j,t}, \tag{10}$$

where $DU_{i,j,t} = 1$ and $DT_{i,j,t} = \left(t - T_{i,j}^b\right)$ for $t > T_{i,j}^b$ and 0 otherwise. $T_{i,j}^b = \lambda_{i,j}^b T$ is the time when occurs the jth break, $j = 1, \cdots, m_i$, $i = 1, \cdots, N$, $\lambda_{i,j}^b \in \Lambda$ and $\Lambda \in [0, 1]$. The cointegration vector $(\delta_{i,t})$ in equation (4) depends on time such that

$$\delta_{i,t} = \delta_{i,j} \quad \text{for } T_{i,j-1}^c < t \leq T_{i,j}^c, \tag{11}$$

with $T_{i,0} = 0$ and $T_{i,n_i+1}^c = T$. $T_{i,j}^c = \lambda_{i,j}^c T$ denotes the jth time of the break, $j = 1, \cdots, n_i$, for the ith unit, $i = 1, \cdots, N$ and $\lambda_{i,j}^c \in \Lambda$; for more details see Banerjee and Carrion-i Silvestre (2015).

The specification formed by equations (4)–(11) nests several models: **Model 1**: no linear trend and stable cointegration vector, that is, $\beta_i = \gamma_{i,j} = 0 \;\; \forall i, j$ in (10) and $\kappa_i = 0 \;\; \forall i$ in (8); and $\delta_{i,j} = \delta_i \;\; \forall j$ in (11); **Model 2**: stable trend and stable cointegration vector, that is, $\beta_i \neq 0 \;\; \forall i$ and $\gamma_{i,j} = 0 \; \forall i, j$ in in (10); and $\delta_{i,j} = \delta_i \;\; \forall j$ in (11); **Model 3**: changes in the level and trend and stable cointegration vector, that is, $\beta_i \neq \gamma_{i,j} \neq 0 \;\; \forall i, j$ in (10); and $\delta_{i,j} = \delta_i \;\; \forall j$ in (11); **Model 4**: no linear trend and the possibility of multiple breaks that can affect the level and the cointegration vector, that is, $\beta_i = \gamma_{i,j} = 0 \;\; \forall i, j$ in (10) and $\kappa_i = 0 \;\; \forall i$ in (8); **Model 5**: stable trend and the possibility of multiple breaks that can affect the level and the cointegration vector, that is, $\beta_i \neq 0 \;\; \forall i$ and $\gamma_{i,j} = 0 \; \forall i, j$ in in (10); **Model 6**: changes in the level, trend and in the cointegration vector.

Therefore, in case time series do not present deterministic trends **Model 1** and **Model 4** should be excluded. Otherwise, if ones tests for the possibility of breaks in the cointegration vector, and the series have a clear deterministic trend, **Model 5** and **Model 6** are the proper candidates. However, **Model 6** has the inconvenience that break's dates are assumed to be known and therefore they are not estimated. Overall, the final choice of the model depends on the features of the time series that are analyzed.

III. Data

To reach a comprehensive view of energy sector valuation, we test the present value model using subsector and firm-level data. We use the Datastream Industry Classification based on the Global Industry Classification Standard from MSCI to select a data set of industry indexes of the following types of energy firms: oil exploration and production (*explorers* & *producers*) and integrated firms in the oil industry (*integrated*). Sector indexes are constructed to prevent overlapping and are consistent across countries.[8]

The sector classification distinguishes two types of subsectors. The exploration and production subsector refers to the initial part of the oil value chain when firms look for new oil resources and bring them to the surface. The main outputs are oil and natural gas that are then resold to other industries. The other subsector, named integrated, aggregates companies that are on all the value chain of the oil or natural gas business, including discovering, obtaining, producing, refining, and distributing oil and natural gas. Oil is transformed into an array of products, including gasoline, jet fuel, and other distillates, which are used in other industry businesses.

We draw data of subsector indexes from the following countries: Canada, Japan, the United Kingdom and the United States, which are among the largest economies in the world and have developed stock markets. Canada, the United Kingdom and the United States are also oil producers. In addition, we collect data from firms in each subsector. We draw the following variables: prices (P), dividends per share (DPS) and dividend-price ratios known as dividend yield (DY). The data set goes from June 1990 to May 2017, and we use end of the month prices. A more detailed summary of the variables can be found in Table C.1 in the Appendix.

In addition, we draw data from the stock market indexes of the sample countries and oil prices. The relationship between securities and the market portfolio returns is a pillar concept in

[8]Further detail on industry classification can be seen at https://www.msci.com/gics.

finance (see e.g. Treynor, 1961; Sharpe, 1964; Lintner, 1965a,b; Mossin, 1966). Thus, our analysis controls for this equilibrium relationship. To proxy the market portfolio, we use Datastream stock market price indexes (*market*) of the countries analyzed which are value-weighted price indexes. Figure C.1 in the Appendix shows the stock market price indexes for the countries in the sample. We have rebased values such as the first observation equals one in the beginning of the sample, to visually compare the different stock markets. The Canadian, UK, and US stock markets show a growing trend in the period, while the Japanese stock market is mostly flat at during the sample period. Despite the growing trend, there are periods of sharp falls consistent with the well-documented cyclical behavior of stock markets.

Oil price (*oil*) is proxied by the price of the oil Brent and is given in US dollars per barrel (U$/BBL). Figure 1 depicts the price of oil in the sample period. Oil prices show different levels through time. Until 2003, price fluctuates in the range of US $20-40 per barrel. After that, oil prices escalate until mid 2008 where they reach US $150 per barrel. Then, oil prices have a sharp fall and rebound again until end of 2014. The last values hover around US $50 per barrel.

[Figure 1 around here]

As is customary in the literature, all nominal time series are in US dollars and are deflated to obtain real prices, with the US Consumer Prices Index adjusted seasonally. Logarithms are applied to prices, dividends and the dividend yield. Given that some firms do not pay dividends, they cannot be included in the analysis. Table C.2 shows the final sample of firms. Most of the firms in the sample are from the United States. Three are from Canada and two are from the United Kingdom. We have twelve firms from the production and exploration subsector and eight from the integrated subsector.

Our methodology accounts for structural breaks, so we proceed with a visual inspection of the dividend yield. Figure 2 depicts the dividend yield for the *explorers & producers* subsector. With the exception of Japan, the figures always suggest two different periods. For instance, in Canada there is a first subperiod until 2003, where the dividend yield ranges between zero and two percent, and then there is an increase in the dividend yield that ranges between two and four percent for the rest of the sample period. The United Kingdom shows the reverse pattern: in the initial period, the dividend yield tends to be high, but ranges between zero and two percent after 2003. In the United States, the pattern is similar to the United Kingdom. In Japan, the dividend yield does not change much in the time period. Figure 3 shows the value of the dividend yield for the *integrated* subsector. The values are smoother than for the *explorers* & *producers* subsector, we find several spikes only for the United Kingdom. Finally, Figures C.2-C.3 in the Appendix depict the dividend yield for each of the firm samples. We see a lot of heterogeneity on the dividend yield profile, but most of the values range between zero and five percent. In the next section, we formally test for the existence of stationarity with breaks on the dividend yield.

[Figure 2, Figure 3, around here]

Summary statistics Table I describes the summary statistics of the dividend yield of the subsectors *explorers* & *producers* and *integrated* and by country. The mean is generally higher for the *integrated* subsector, but the *explorers* & *producers* subsector has a wider range between maximum and minimum values. For instance, for Canada the dividend yield ranges between a maximum of 6.5 and minimum of 0.47 percent. We can also see the dispersion by looking at the standard deviation that is larger for the *explorers* & *producers* than for the *integrated* subsector. In the latter, the dividend yield tends to be smoother. Only for the United Kingdom are the standard deviation and kurtosis lower, corroborating the conclusions of the visual inspection of the figures. The summary statistics of the dividend yield by firm, presented in Table II, confirm that most of the values tend to range from zero to five percent.

[Table I and Table II around here]

Country and firm variables are likely to have cross-sectional dependence. To check whether the variables feature cross-sectional dependence, we run the Lagrange multiplier (LM) test presented by Breusch and Pagan (1980) and a cross-sectional dependence (CD) test by Pesaran (2004).

The null hypothesis in the two tests is that the variables are cross-sectional independent. The results are reported in Tables III and Table IV, for sectors and firms, respectively.

The test results show that both prices and dividend yields of *explorers* & *producers* and *integrated* subsectors show cross-sectional dependence. The exception seems to be the dividends (d) where the LM and CD tests show different conclusions for the *explorers* & *producers* subsector. Given that the CD test performs better in small samples, we tend to follow its result and conclude that dividends of *explorers* & *producers* subsector have cross-sectional dependence. We also reject the cross-sectional independence hypothesis for stock market indexes (*market*).

In Table IV, the cross-sectional dependence tests for the panel of firms indicate that the null hypothesis of cross-sectional independence is rejected. Again, the exception is the variable dividends for *explorer* & *producers* subsector where the tests provide conflicting results, but based on Pesaran's CD test, we conclude for cross-sectional dependency.

[Table III and Table IV around here]

IV. Tests of Stationarity

The first approach to analyze valuation is based on the observation of the dividend yield ratio. If markets use the present-value model, then it should exist a stable relationship between price and dividends and the logarithm of the dividend yield (i.e., the difference between the logarithm of the dividend and stock price) follows a stationary process, assuming a time-varying discount rate (e.g. Campbell and Shiller, 1988b,a; Diba and Grossman, 1988).

To test this, we use panel unit root tests from Bai and Carrion-I-Silvestre (2009) (see description in section II), which have been applied in several works, including Chen and Lee (2007); Narayan and Smyth (2008); Apergis and Payne (2010); Cerqueti and Costantini (2011); Lean and Smyth (2014). The null hypothesis is that the dividend price ratio has a unit root (I(1)). The rejection of the null hypothesis supports that the dividend price ratio is stationary, which means that there is a stable relation between prices and dividends.

Results for subsectors Table V shows the results of the panel unit root tests of Bai and Carrion-I-Silvestre (2009), which consider structural breaks in mean and trend for the subsectors. As shown in Table V, we cannot reject the null hypothesis, except for the dividend yield of *explorers & producers* subsector. Thus the test indicates that for this subsector the dividend yield is stationary with breaks in the mean, while with breaks in the trend we cannot reject the null hypothesis, which seems consistent with the dividend yield having different levels in two subperiods in Figure 4. For the series that are stationary in breaks, we can compute the break dates using the procedure from Bai and Carrion-I-Silvestre (2009), which are depicted in Figure 4 (the vertical line).

[Table V and Figure 4 around here]

For *explorers & producers* subsector, we see that the break dates seem to distinguish two periods with different levels of dividend yield coherently with the conclusions from visual inspection on section III. For Canada, the estimated break date separates the low level range from the high level range. For the United Kingdom, the estimated break separates the high level period from the low-level period, and similarly for the United States. The break dates for the United Kingdom and United States are very close, September and August 2004. The break date for Canada is in November 1998.

The results displayed in Table V for the *integrated* subsector show that the unit root hypothesis is rejected only for the variable dividends. For all the other variables, we cannot reject the null hypothesis of the unit root, all variables are integrated of order one (I(1)). The identified breaks dates are for Canada in June 1999 and June 2004, highlighting the rapid increase from 1999 to 2004, and then the period after 2004 (the dates are displayed in Figure 5).

[Figure 5 around here]

Results for Firms Table VI shows the results of the unit root tests for the panel of firms. To validate the price dividends relation, the unit root hypothesis needs to be rejected. The results show that all variables are non-stationary including the dividend yield, thus we do not find support for the present value model for the panel of firms.

[Table VI around here]

In the next section, we use another approach to analyse the strength of the economic relationship between prices and dividends. We test the hypothesis of cointegration between those variables.

V. Tests of Cointegration

Another angle used to explore the long-term relationship between prices and dividends are cointegration methods that allow the investigation of the long-run dynamics of variables, focusing on stationary relationships among variables that are non-stationary in levels.

Given that the series of the logarithm of prices and dividends present a trend for the two subsectors and for the majority of countries, we have considered Model 5 for testing the null hypothesis of no cointegration. Table VII and Table VIII present the results of the cointegration tests for sectors and for firms, respectively.

We consider that the structural breaks, if they exist, affect the deterministic component and the cointegration vector at the same moment in time. The maximum number of factors allowed for the subsectors is four, while for the firms in the *explorers* & *producers* is thirteen and eight for the firms in the *integrated* subsector. For estimating the number of common factors we have use the BIC (Bayesian Information Criterion) as in Bai and Ng (2004).

Results for Sectors The null hypothesis is of "no-cointegration", which implies that prices do not relate with dividends.

Table VII shows for *explorers* & *producers* subsector that when one break is assumed, the tests indicate cointegration between price and dividends. But, given the length of the time series, it is not very probable that there is only one break. Allowing for two breaks in the trend and cointegration vector, we observe that there is not cointegration between price and dividends for both sectors.

The break dates for the subsector *explorers & producers* are close in time for the different countries, around 2000 and 2008, except for Canada that is 2004 and 2013, see Figure 6. The dates coincide with the rising of price of oil and then the sudden fall with the global financial crisis.

For *integrated* subsector, the break dates for the United Kingdom and the United States are around September 2002 and 2008, see Figure 7. For Japan the dates are 1997 and 2008, and for Canada the dates are 2004 and 2013.

[Table VII, Figure 6 and Figure 7 around here]

Nasseh and Strauss (2004) and Goddard et al. (2008) raise some caution about the previous model, arguing that market efficiency implies that only anticipated dividends at time t affect the price at time t and propose regressing dividends on prices. They argue that the previous model leads to an overestimation of the coefficient on dividends. Moreover, it is well acknowledged that the regressor should have more variability to improve the parameter estimation. Stock prices have higher volatility than dividends, therefore making them more suitable to be on the right hand side. Following the above works, we test the following model

$$d_{it} = b_1 + b_2 \cdot p_{it} + \epsilon_{it}.$$

The results of the new model estimation are displayed on Table VII, and the null hypothesis of "no-cointegration" is not rejected.

We extend the basic model with other variables of interest. The first one is oil prices (oil), we posit the hypothesis that the valuation of the energy sector is related with oil price because oil is the main output of the *explorers & producers* sector. We also expect that the value of *integrated* firms is related to oil because oil is present through its value chain. We test formally the model[9]. The null hypothesis of "no-cointegration" is not rejected, so we do not find evidence supporting a long-term relationship between valuation of the energy sector and the price of oil.

Next, we posit the hypothesis that valuation of the sector is related with the overall market valuation, since the relationship between prices of financial assets and the stock market is well rooted in financial economics (see e.g. Treynor, 1961; Sharpe, 1964; Lintner, 1965a,b; Mossin, 1966). The model is formally tested[10] and the results are presented in Table VII. The null hypothesis "no-cointegration" is rejected for the model with two breaks for $explorers\&producers$, so we find evidence of a long-term relationship between the sector and the overall market valuation.

Results for firms We do a similar analysis for firms, shown in Table VIII. Cointegration tests for the different models show that the null hypothesis of "no-cointegration" cannot be rejected; except for the firms in the *explorers* & *producers* subsector, when we consider one break, we reject the null of "no-cointegration". Although, as mentioned above, given the length of the time series the existence of only one break is not probable.

Overall, the evidence for cointegration between prices and dividends is weak. We should thus be cautious reaching conclusions about the present value model.

[Table VIII around here]

VI. Variance Decomposition Analysis

According to the present value model, the price of any asset can be written as a sum of its expected future cash flows discounted to the present using a set of discount rates. Therefore, stock prices are impacted by changes in expectations of future cash flows and in the rates used to discount them to the present (Campbell and Shiller, 1988b). We follow the analysis of Campbell (1991) that distinguishes between asset price movements driven by rationally expected cash

[9] We take a visual inspection of the relationship between index prices and oil prices. They are presented in Table VII and Table VIII.

[10] An interested reader can make a visual inspection of the this relationship in Figures C.8 and C.9.

flows and by discount rates. He argues that investor sentiment affects discount rates, but cannot directly affect cash flows.

We use a Vector Autoregressive analysis to study the impact of changes of expected cash flows and discount rates (see e.g. Campbell, 1991; Campbell and Shiller, 1988b; Campbell and Vuolteenaho, 2004).

Let the k-variate homogeneous panel VAR of order p with panel-specific fixed effects be specified as:

$$\mathbf{Y}_{it} = \mathbf{Y}_{it-1}\mathbf{A}_1 + \mathbf{Y}_{it-2}\mathbf{A}_2 + ... + \mathbf{Y}_{it-p}\mathbf{A}_p + \mathbf{u}_{it} + \mathbf{e}_{it}, \tag{12}$$

where $i \in \{1, ..., N\}$ and $t \in \{1, ..., T_i\}$. $\mathbf{Y}_{it}$ is a $(1 \times k)$ vector of dependent variables, $\mathbf{u}_i$ is a $(1 \times k)$ vector of dependent variable-specific panel fixed effects and $\mathbf{e}_{it}$ is a $(1 \times k)$ vector of idiosyncratic errors. $\mathbf{A}_1 ... \mathbf{A}_p$ are $(k \times k)$ matrices of the reduced-form parameters to be estimated, innovations are characterized by $E(\mathbf{e_{it}}) = \mathbf{0}$, $E(\mathbf{e}'_{it}\mathbf{e}_{it}) = \mathbf{\Sigma}$ and $E(\mathbf{e}'_{it}\mathbf{e}_{is}) = \mathbf{0}$ for all $t > s$. Finally, the cross-sectional units share the same underlying data generating process.

The dividend yield (dy) is our proxy of valuation. To proxy for cash flow news we will use the return on equity ratio (roe) as in Cohen et al. (2003); Campbell et al. (2010). To proxy for changes in interest rate we use the real interest rate (rir) like Chortareas and Noikokyris (2014).

We distinguish between positive and negative changes in the two variables of interest. First, the use of asymmetric specifications improves the model's ability to detect exposures to shocks. Second, research shows that investors tend to react more to bad news than to good news. Downside cash flow risk and downside discount rate risk are significantly priced and typically carry the largest premia (see e.g. Botshekan et al., 2012).

The sensitivity of the VAR results can be reduced by including state variables (Campbell et al., 2010), thus a set of control variables such as the excess log return on the market ($market$), the Brent crude oil return in logs (oil) and the exchange rate return in logs (rer).

The model is estimated using the generalized method of moments (GMM) and the lags of the panel VAR are selected using the selection procedures for GMM estimation proposed by Andrews and Lu (2001). Given these measures p is selected equal to one. The estimated models are stable given that the eigenvalues are found to be inside of the unit circle and the instruments pass the overidentification test of Hansen (1982).

The estimation results are reported in the appendix in Table C.3 -Table C.6 for the sake of space.[11] Results show that news on return on equity impact UK *explorers & producers* and US *integrated* sectors, while news in discount rate impact Japan and Canada *explorers&producers*, and the UK, Japan, and Canada *integrated* sectors. This result is in line with evidence in the literature (Campbell and Ammer, 1993; Ammer and Mei, 1996; Van Binsbergen and Koijen, 2010) reporting that stock index returns change mostly with discount rate news. Moreover, the results validate the asymmetric specification as the effects are not the same for increases and decreases of variables. Results seem to indicate that shocks in interest rate affect valuation more than shocks on the fundamentals.

The non-linear effect of changes in cash flow and discount rate might explain why valuation is not explained by the fundamentals. In the next section we test the presence of bubbles.

VII. Bubbles tests for the energy sector

Given that our results are not conclusive regarding the link between prices and fundamentals, in this section, we formally test the existence of bubbles in valuation using the tests from Phillips and Yu (2011) and Phillips et al. (2015) that detect explosive behavior in time series.

The traditional procedure is based on unit root tests as the standard ADF or the PP tests. However, these tests lose power when a process changes from a unit root to a mildly explosive root or vice versa. To overcome this drawback, Phillips and Yu (2011) propose the supreme of recursively determined ADF t-statistics, named as SADF. This test is suitable when the sample period includes a single bubble. However, when there are multiple bubbles Phillips et al. (2015) show that the power of the SADF test may decrease. An alternative way to proceed in these cases

[11]Before preceding with the interpretation of the estimates, we check if the VAR is stable, that is, if it is invertible. Invertibility ensures a known interpretation of the impulse response functions and of the forecast error variance decomposition (FEVD) presented below. Given that all moduli of the companion matrix are strictly less than one, we conclude that the panel VAR is stable; see Figure C.12 and Figure C.13. We also run unit-root tests on the endogenous variables and we reject the null of unit root in all cases.

is to apply the generalized SADF test proposed by Phillips et al. (2015), called GSDAF. The GSADF performs well in detecting explosive behavior in multiple episodes because it evaluates additional sub-samples of the full period and has greater window flexibility.

Following Phillips et al. (2015), we apply the SADF and GSADF tests to date potential bubble periods. The tests are nevertheless applied to univariate series of subsectors and to the inverse of dividend yield, that is, the inverse the price-dividend ratio. A high price dividend ratio means a high price in comparison with the fundamentals.

Table IX reports the test statistics values and the critical values for these two tests obtained by simulation with 2,000 replications for a sample size of 343 observations. We observe that the null hypothesis of "no bubbles" is rejected at the 5% significance level for the UK *explorers & producers* subsector, at 10% for the US *explorers & producers* subsector, and at 1% for Canada *integrated* subsector. For the rest of the countries, the tests do not detect the existence of any bubble in the price dividend ratio.

To date the bubble periods, we compare the backward GSADF statistic sequence with the 95% GSADF critical value sequence, which are obtained from Monte Carlo simulations with 2 000 replications. Figure 8 and Figure 9 date potential bubble period identified by the procedure, represented by grey vertical lines. In the United Kingdom, the tests highlight bubbles from December 1996 to January 1997, in August-September of 1998, in January of 1999 and in 2002 (September, November). In the United States, there is evidence of bubbles in July 2005. In Canada in October of 1997 and in August-September of 2005.

To check if valuation is driven by high prices, we test the bubble hypothesis for prices. Table X reports the test statistics values and the critical values for these two tests. The tests reject the hypothesis of "no-bubbles" for Canada, the United Kingdom and the United States for *explorers & producers* at 1 % and Canada, the United Kingdom and the United States for *integrated* at 1% also.

Again we use the graphical procedure to date the bubble periods, which highlights several periods: for instance for the UK *explorers & producers*, the dates are October 1996 to March

1997, July 1998 to February 1999, March-November 2004, then a long period from 2005 to July 2008. For *integrated* in Canada, the dates are July-December 1997, December 2003 to December 2004, July 2004 to August 2008.

Overall, these periods of high prices match the bubbles periods of the price dividend ratio, and the bubble periods in valuation seem to be driven by high prices.

[Table IX, Figure 8, Figure 9, Figure 10 and Figure 11 around here]

VIII. Robustness

To verify the robustness of the results, we repeated the stationarity tests and cointegration tests for the individual time series.[12] We applied a battery of unit root tests, such as: the traditional ADF, the DF-GLS by Elliott et al. (1996), the PP test by Phillips and Perron (1988), the Zivot and Andrews (1992) test, and the Clemente et al. (1998) unit root tests. These latter tests consider the existence of potential breaks.

The results of the univariate unit root tests for the dividend yield for each of the countries' subsectors support the results of the panel unit root tests. The series of the logarithms of the dividend yields are not stationary, rather, they are integrated of order one for all countries.

Regarding the cointegration tests with breaks, the results confirm the absence of cointegration between prices and dividends. The only exception is the U.S. *explorers & producers* subsector, for which there is cointegration with breaks between prices and dividends.

We also repeat the tests at the firm level. The results of the non-stationarity of the log dividend yield are confirmed; all the series have a unit root with at least one break in the mean. For the cointegration tests at the firm level, there are some cases in which the results confirm cointegration between prices and dividends: a firm for Canada and Japan, and some cases for the United States, mainly firms in the subsector *integrated.*

[12] All the results are available upon request from the authors.

Overall the individual time series tests confirm the panel results. We do not find stationarity of the dividend yield for sectors and firms. Nevertheless, we find cointegration of prices and dividends for US *explorers* & *producers* and some isolated cases of some firms.

IX. Concluding Remarks

The energy sector has been crucial to sustaining the pace of industrial production and transportation development and to meet the growing consumption demands of modern societies. This work analyses the relationship between valuation and the fundamentals in this sector within the framework of the present value that establishes an economic relationship between prices and dividends. Our empirical approach makes use of panel stationary and cointegration tests in a sample of subsectors and firms from the energy sector in Canada, Japan, the United Kingdom, and the United States. The tests of stationarity and cointegration account for breaks in the time series.

Overall, the evidence casts doubt on the role of fundamentals in driving valuation. Stationarity and cointegration tests fail to provide sound evidence on the relationship with the fundamentals. A variance decomposition analysis shows that mainly shocks in discount rates, interpreted as investor sentiment, explain changes in valuation. Further tests detect explosive bubbles on the exploration and production sector in the United Kingdom and in the integrated subsector for Canada in the late 1990's and around 2005 that are driven by high prices.

Our work provides new insights and contributes to the debate on the value drivers of investments in the energy industry. The paper provides some answers, but also spurs new avenues of research to fully clarify the drivers of value in the energy sector.

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Tables

Table I
Summary Statistics for the Dividend Yield–Sector Data

	Max	Min	Mean	SD	Skewness	Kurtosis	Jarque-Bera
subsector: *explorers & producers*							
Canada	6.500	0.470	2.272	1.407	0.358	2.213	15.081***
Japan	3.250	0.710	1.860	0.564	0.194	2.364	7.405*
UK	6.530	0.070	1.406	1.270	1.331	4.455	122.735***
US	4.930	0.560	1.824	0.829	1.041	4.130	74.887***
subsector: *integrated*							
Canada	3.500	0.590	2.098	0.725	0.023	2.044	12.205***
Japan	3.920	0.700	2.071	0.902	0.245	1.725	24.861***
UK	7.910	2.360	4.205	1.278	0.949	3.086	48.163***
US	5.240	1.710	3.158	0.902	0.650	2.322	28.645***

Table II
Summary Statistics for the Dividend Yield–Firm Data

This table presents the summary statistics of the dividend yield of *producers* & *explorers* and *integrated* subsectors for sample countries. The sample period ranges from 1988:11 through 2017:05. By column, we report the maximum, the minimum, the mean, the standard deviation (SD), the skewness, the kurtosis, and the Jarque-Bera (normality) test. Variables are described in Table C.1 in the Appendix.[***,**,*] denotes statistical significance at 1, 5 and 10 percent level, respectively.

	Max	Min	Mean	SD	Skewness	Kurtosis	Jarque-Bera
subsector: *explorers* & *producers*							
EOG Resources Inc.	1.160	0.160	0.583	0.190	0.504	3.228	14.419***
Occidental Petroleum	13.610	1.200	3.632	1.843	2.075	11.144	1127.796***
Valero Energy	4.710	0.350	1.715	0.951	0.937	3.498	50.704***
Anadarko Petroleum	2.760	0.280	0.730	0.315	1.772	9.420	725.995***
Apache Corp.	2.610	0.400	0.969	0.471	1.251	3.824	93.725***
Noble Energy	2.390	0.260	0.771	0.366	1.219	5.048	136.891***
Cabot oil & gas Corp.	1.520	0.110	0.595	0.331	0.453	2.111	21.749***
EQT Corp.	5.390	0.110	2.387	1.304	-0.278	2.216	12.457***
Murphy Oil Corp.	8.150	0.760	2.378	1.038	1.201	6.981	291.851***
Hollyfrontier Corp.	6.800	0.480	2.201	1.290	1.237	4.113	99.340***
San-Ai Oil	4.090	0.360	1.930	0.873	-0.019	2.341	5.887*
Enerplus Corp.	26.250	0.940	10.892	4.454	0.310	3.507	8.670***
Encana Corp.	4.800	0.470	2.079	0.989	0.586	3.069	18.613***
subsector: *integrated*							
Exxon Mobil	5.290	1.490	2.957	0.984	0.731	2.278	35.863***
Chevron	5.430	2.450	3.565	0.632	0.571	2.588	19.896***
ConocoPhillips	7.570	1.770	3.305	0.938	0.660	3.707	30.248***
Hess Corp.	2.710	0.320	1.178	0.484	0.909	3.802	53.321***
BP	11.010	0.880	4.247	1.692	0.909	3.421	46.970***
Royal Dutch Shell	8.150	2.660	4.634	1.110	0.585	3.117	18.675***
Showa Shell Sekiyu	5.850	0.310	2.303	1.286	0.210	2.198	11.063***
Imperial Oil	4.710	0.610	2.049	1.180	0.608	1.925	35.588***

Table III
Cross-sectional dependence test results for *explorers* & *producers*, *integrated* and *market*

This table presents the summary statistics of the dividend yield of *producers* & *explorers* and *integrated* subsectors for sample countries. The sample period ranges from 1988:11 through 2017:05. By column, we report the maximum, the minimum, the mean, the standard deviation (SD), the skewness, the kurtosis, and the Jarque-Bera (normality) test. Variables are described in Table C.1 in the Appendix.[***,**,*] denotes statistical significance at 1, 5 and 10 percent level, respectively.

	Breusch and Pagan (1980) LM test	Pesaran (2004) test
Subsector: explorers & producers		
p	688.684	13.297
	(0.000)	(0.000)
d	8.158	2.664
	(0.229)	(0.091)
dy	203.110	-5.921
	(0.000)	(0.000)
Subsector: integrated		
p	591.408	10.342
	(0.000)	(0.000)
d	8.136	26.010
	(0.228)	(0.000)
dy	183.362	9.730
	(0.000)	(0.000)
Stock market indexes		
market	738.447	8.042
	(0.000)	(0.000)

Table IV
Cross-sectional dependence test results for the panel of firms in *explorers* & *producers* and *integrated* subsectors

This table presents the summary statistics of the dividend yield of *producers* & *explorers* and *integrated* subsectors for sample countries. The sample period ranges from 1988:11 through 2017:05. By column, we report the maximum, the minimum, the mean, the standard deviation (SD), the skewness, the kurtosis, and the Jarque-Bera (normality) test. Variables are described in Table C.1 in the Appendix.[***,**,*] denotes statistical significance at 1, 5 and 10 percent level, respectively.

	Breusch and Pagan (1980) LM test	Pesaran (2004) test
Subsector: explorers & producers		
p	5668.921	89.023
	(0.000)	(0.000)
d	89.690	72.117
	(0.172)	(0.000)
dy	1756.959	24.566
	(0.000)	(0.000)
Subsector: integrated		
p	2703.876	41.824
	(0.000)	(0.000)
d	156.831	67.647
	(0.000)	(0.000)
dy	1494.969	28.747
	(0.000)	(0.000)

Table V

Panel unit root test results for *explorers* & *producers*, *integrated* and *market*

Z,P_m denote the statistics developed by Bai and Carrion-I-Silvestre (2009), whose 5 percent critical values are 1.645 and -1.645, respectively. Z^* and P_m^* refer to the simplified MSB statistics. The number of common factors is 3. The maximum number of breaks allowed is 3. p is the log of real prices, d is the log of real dividends and dy is the log of the dividend yield, *market* is the market log of the stock market index. Variables are defined in Table C.1.

	Break in the mean		Break in the trend			
	Z	P_m	Z	P_m	Z^*	P_m^*
Subsector: explorers & producers						
p	-1.164	0.348	1.380	-1.634	1.380	-1.634
d	-0.330	-1.010	2.326	-1.756	2.014	-1.729
dy	2.636	-1.814	-0.805	-0.156	-1.308	0.685
Subsector: integrated						
p	0.323	-1.366	-1.394	1.207	-1.394	1.207
d	2.764	-1.825	1.517	-1.661	1.517	-1.661
dy	-1.129	0.226	-1.547	2.098	-1.547	2.098
Stock market indexes						
market	1.263	-1.630	1.589	-1.674	1.589	-1.674

Table VI
Panel unit root test results for the panel of firms in *explorers* & *producers* and *integrated* subsectors

Z,P_m denote the statistics developed by Bai and Carrion-I-Silvestre (2009), whose 5 percent critical values are 1.645 and -1.645, respectively. Z^* and P_m^* refer to the simplified MSB statistics. The number of common factors is 3. The maximum number of breaks allowed is 3. p is the log of real prices, d is the log of real dividends and dy is the log of the dividend yield. Variables are defined in Table C.1. Firms are classified in each of the two subsectors see Table C.2. [***,**,*] denotes statistical significance at 1, 5 and 10 percent level, respectively.

Variables	Break in the mean		Break in the trend			
	Z	P_m	Z	P_m	Z^*	P_m^*
Subsector: explorers & producers						
p	-0.275	1.032	-1.336	0.689	-1.336	0.689
d	1.380	-2.275^*	1.263	-0.016	1.582	-0.078
dy	-1.944	5.141	-1.135	0.973	-0.896	0.869
Subsector: integrated						
p	-0.695	1.086	-1.702	4.058	-1.702	4.058
d	1.378	-0.298	-0.789	0.483	-0.789	0.483
dy	-1.608	6.055	-1.160	2.949	-1.160	2.949

Table VII: Panel cointegration test results for subsectors *explorers* & *producers* and *integrated* new

This table presents the results of the cointegration tests of Banerjee and Carrion-i Silvestre (2015) for the equations reported in each panel. p is the log of real prices, d is the log of real dividends, *oil* is the log of price of oil and *market* is the log of the stock market index. Variables are defined in Table C.1. Maximum numbers of factors allowed is max $r_{max} = 4$. BIC is used to estimate the optimum number of common factors $\widehat{r}$. Model 5 (i.e. stable trend with the presence of one and two structural breaks) of Banerjee and Carrion-i Silvestre (2015) test is chosen. For brevity, we do not report the full results here but are available upon requests from the authors. $\widehat{r}^P$ are the common factors estimated parametrically while $\widehat{r}^{NP}$ are the common factors estimated nonparametrically.

Cointegration relation	subsectors									
	Panel A: *explorers* & *producers*					Panel B: *integrated*				
one break	% ind. rejections at 5%	Test Statistic	$\widehat{r}$	$\widehat{r}^P$	$\widehat{r}^{NP}$	% ind. rejections at 5%	Test Statistic	$\widehat{r}$	$\widehat{r}^P$	$\widehat{r}^{NP}$
$p_{it} = \alpha_0 + \beta_0 d_{it} + \epsilon_{it}$	100%	-2.514	3	2	2	0%	-0.199	3	3	3
$d_{it} = \alpha_0 + \beta_0 p_{it} + \epsilon_{it}$	0%	2.681	3	3	3	0%	1.925	3	3	3
$p_{it} = \alpha_0 + \beta_0 oil_{it} + \epsilon_{it}$	0%	0.215	3	2	2	0%	0.033	3	3	3
$p_{it} = \alpha_0 + \beta_0 market_{it} + \epsilon_{it}$	0%	-0.877	3	3	3	0%	0.057	3	3	3
two breaks										
$p_{it} = \alpha_0 + \beta_0 d_{it} + \epsilon_{it}$	0%	0.503	3	2	2	0%	-0.069	3	3	3
$d_{it} = \alpha_0 + \beta_0 p_{it} + \epsilon_{it}$	0%	2.628	3	3	3	0%	1.808	3	3	3
$p_{it} = \alpha_0 + \beta_0 oil_{it} + \epsilon_{it}$	0%	-0.814	3	2	2	0%	0.436	3	3	3
$p_{it} = \alpha_0 + \beta_0 market_{it} + \epsilon_{it}$	100%	-2.326	3	3	3	0%	0.241	3	3	3

Table VIII: Panel cointegration test results for firms

This table presents the results of the cointegration tests of Banerjee and Carrion-i Silvestre (2015) for the equations reported in each panel. p is the log of real prices, d is the log of real dividends, oil is the log of price of oil and $market$ is the log of the stock market index. Variables are defined in Table C.1. Maximum numbers of factors allowed are max $r_{max} = 13; 8$ for firms in the subsector *explorers & producers* and in the subsector *integrated*, respectively . BIC is used to estimate the optimum number of common factors $\widehat{r}$. Model 5 (stable trend with the presence of one and two structural breaks) of Banerjee and Carrion-i Silvestre (2015) test is chosen. For brevity, we do not report the full results here but are available upon requests from the authors. $\widehat{r}^P$ are the common factors estimated parametrically while $\widehat{r}^{NP}$ are the common factors estimated nonparametrically.

Cointegration relation	subsectors									
	explorers & producers					*integrated*				
one break	% ind. rejections at 5%	Test Statistic	$\widehat{r}$	$\widehat{r}^P$	$\widehat{r}^{NP}$	% ind. rejections at 5%	Test Statistic	$\widehat{r}$	$\widehat{r}^P$	$\widehat{r}^{NP}$
$p_{it} = \alpha_0 + \beta_0 d_{it} + \epsilon_{it}$	100%	-2.792	12	11	11	0%	2.989	7	6	5
$d_{it} = \alpha_0 + \beta_0 p_{it} + \epsilon_{it}$	0%	-1.111	12	8	8	0%	2.825	7	6	5
$p_{it} = \alpha_0 + \beta_0 oil_{it} + \epsilon_{it}$	0%	4.261	12	12	12	0%	1.957	7	7	7
$p_{it} = \alpha_0 + \beta_0 market_{it} + \epsilon_{it}$	0%	4.8910	12	8	8	0%	2.138	7	7	7
two breaks										
$p_{it} = \alpha_0 + \beta_0 d_{it} + \epsilon_{it}$	0%	4.559	12	12	11	0%	3.060	7	6	6
$d_{it} = \alpha_0 + \beta_0 p_{it} + \epsilon_{it}$	0%	-1.294	12	7	7	0%	3.352	7	6	6
$p_{it} = \alpha_0 + \beta_0 oil_{it} + \epsilon_{it}$	0%	2.924	12	12	12	0%	2.198	7	7	7
$p_{it} = \alpha_0 + \beta_0 market_{it} + \epsilon_{it}$	0%	4.405	12	10	10	0%	0.066	7	7	7

Table IX
Tests for bubbles in the price-dividend ratio

This table presents the results of the tests by Phillips and Yu (2011) and Phillips et al. (2015) for the price-dividend ratio of the sample countries. The SADF is the sequential ADF test (Phillips and Yu, 2011) and the GSDAF is the generalized SADF (Phillips et al., 2015). [***,**,*] denotes statistical significance at 1, 5 and 10 percent level, respectively.

Country	Test	Test stat.	Finite sample critical values		
			90%	95%	99%
Panel A: Subsector: *explorers & producers*					
Canada	SADF	-0.276	1.153	1.454	1.886
	GSADF	0.188	1.704	1.984	2.614
Japan	SADF	-1.669	1.153	1.454	1.886
	GSADF	0.466	1.704	1.984	2.614
UK	SADF	1.366	1.190	1.421	1.900
	GSADF	2.317	1.991	1.984	2.636
US	SADF	1.244	1.153	1.454	1.886
	GSADF	1.308	1.704	1.984	2.614
Panel B: Subsector: *integrated*					
Canada	SADF	2.623	1.153	1.454	1.886
	GSADF	2.623	1.704	1.984	2.614
Japan	SADF	-1.410	1.153	1.454	1.886
	GSADF	1.687	1.704	1.984	2.614
UK	SADF	0.230	1.190	1.421	1.900
	GSADF	0.397	1.991	1.984	2.636
US	SADF	0.260	1.153	1.454	1.886
	GSADF	0.237	1.704	1.984	2.614

Table X
Tests for bubbles in Prices

This table presents the results of the tests by Phillips and Yu (2011) and Phillips et al. (2015) for the prices indexes. The SADF is the sequential ADF test (Phillips and Yu, 2011) and the GSDAF is the generalized SADF (Phillips et al., 2015). [***,**,*] denotes statistical significance at 1, 5 and 10 percent level, respectively.

Country		Test stat.	Finite sample critical values		
			90%	95%	99%
Panel A: Subsector: *explorers & producers*					
Canada	SADF	7.055	1.153	1.454	1.886
	GSADF	7.055	1.704	1.984	2.614
Japan	SADF	-1.831	1.153	1.454	1.886
	GSADF	0.206	1.704	1.984	2.614
UK	SADF	5.600	1.190	1.421	1.900
	GSADF	5.600	1.991	1.984	2.636
US	SADF	4.139	1.153	1.454	1.886
	GSADF	4.139	1.704	1.984	2.614
Panel B: Subsector: *integrated*					
Canada	SADF	6.243	1.153	1.454	1.886
	GSADF	6.243	1.704	1.984	2.614
Japan	SADF	-0.681	1.153	1.454	1.886
	GSADF	1.151	1.704	1.984	2.614
UK	SADF	1.728	1.190	1.421	1.900
	GSADF	1.728	1.991	1.984	2.636
US	SADF	3.002	1.153	1.454	1.886
	GSADF	3.002	1.704	1.984	2.614

Figures

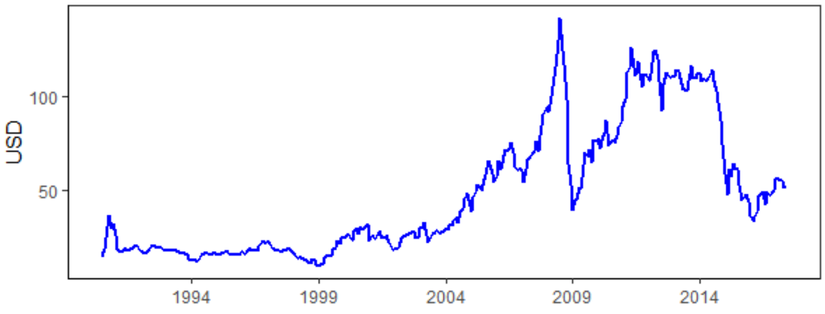


Figure 1. Price of the Brent oil in US dollars per barrel.

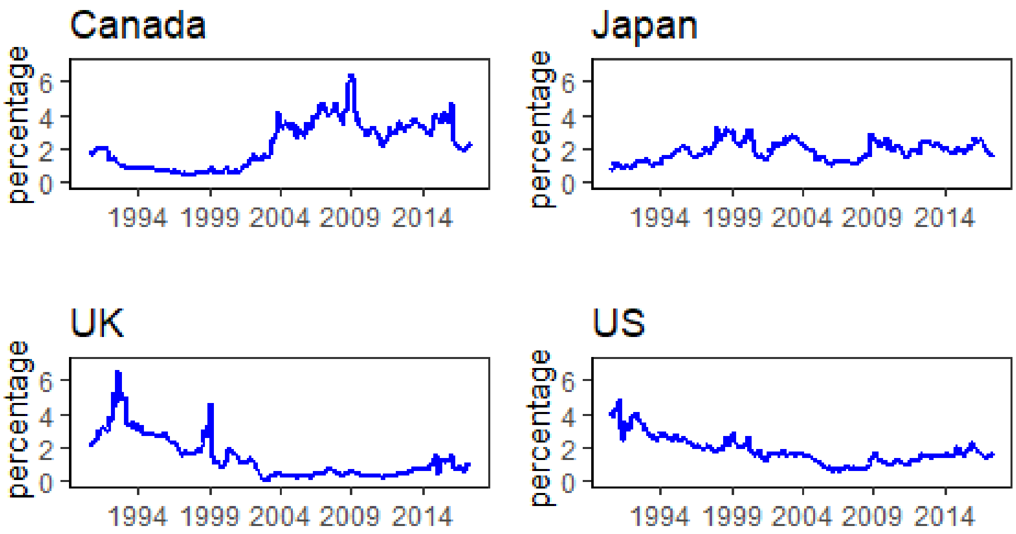


Figure 2. Dividend Yield (in percentage) for *explorers* & *producers* subsector.

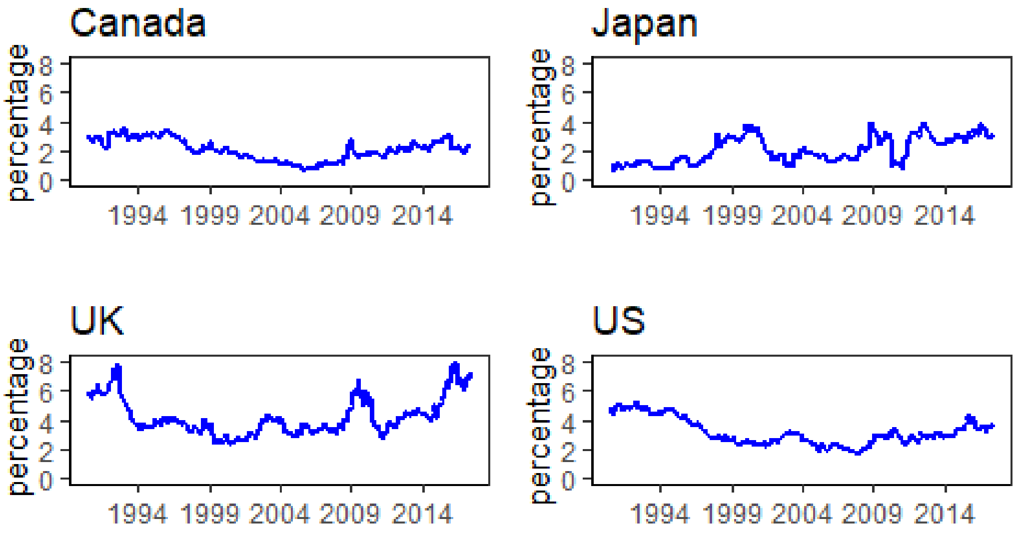


Figure 3. Dividend Yield (in percentage) for *integrated* subsector.

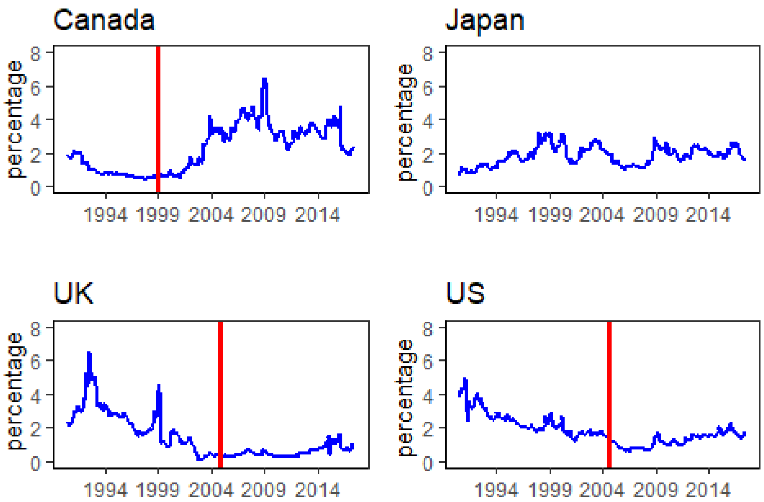


Figure 4. Logarithm of the Dividend Yield for *explorers* & *producers* subsector and break dates (vertical line) obtained with the unit root test by Bai and Carrion-I-Silvestre (2009).

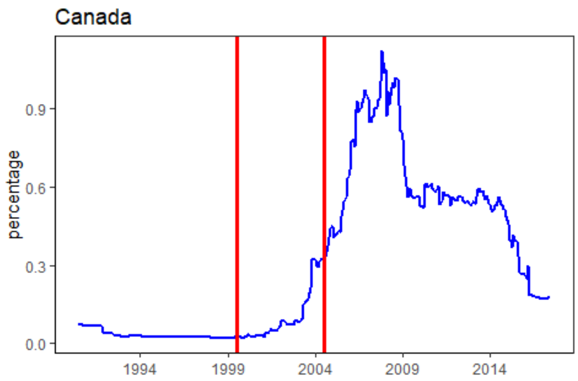


Figure 5. Logarithm of the Dividend Yield for *integrated* subsector and break dates (vertical lines) obtained with the unit root test by Bai and Carrion-I-Silvestre (2009).

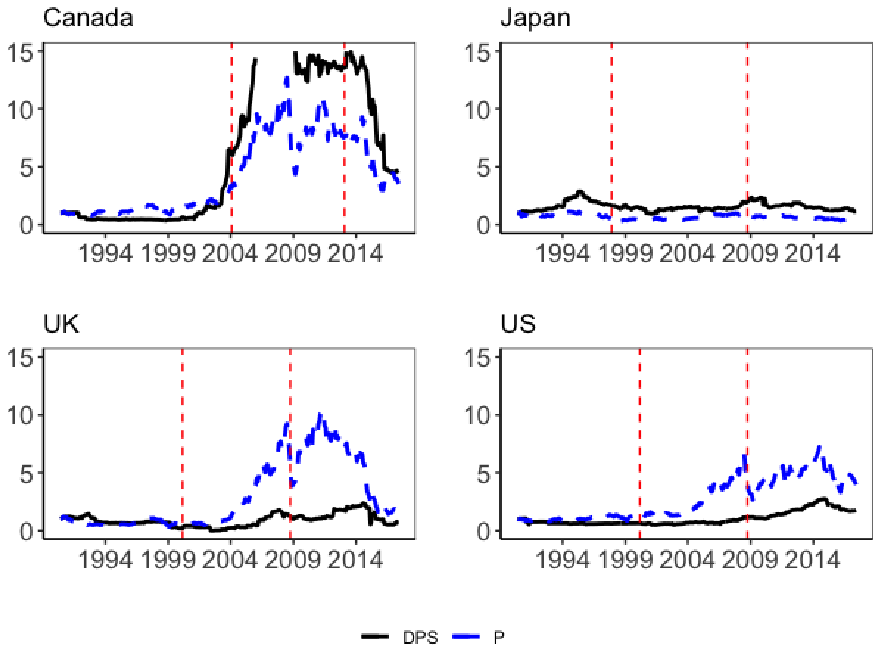


Figure 6. Estimated break dates (vertical line) for the cointegration relationship between prices and dividends for *explorers* & *producers* subsector. Series are rebased to 1 in the first observation. Types of break: Model 5 with two breaks (Banerjee and Carrion-i Silvestre, 2015).

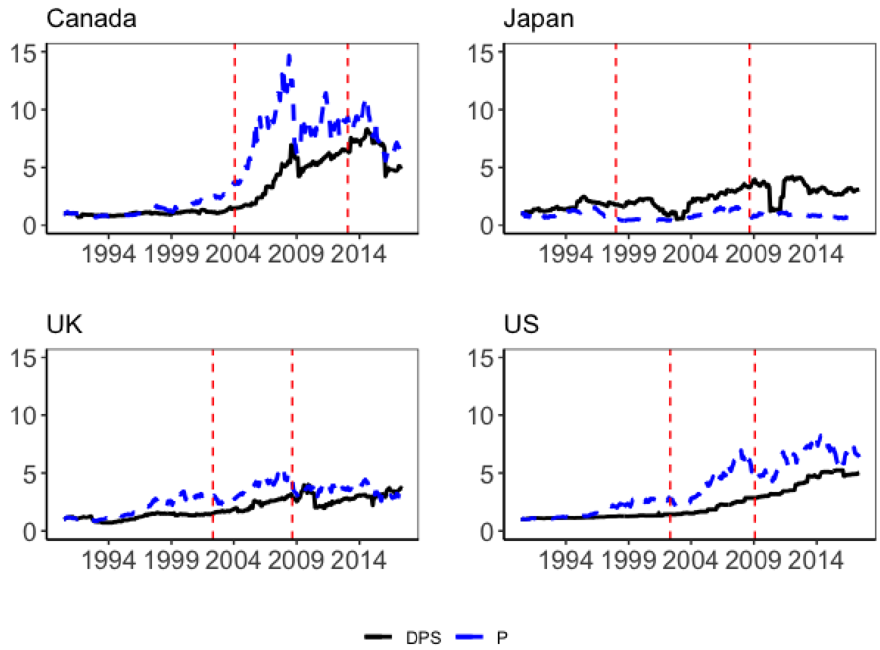


Figure 7. Estimated break dates (vertical line) for the cointegration relationship between prices and dividends for *integrated* subsector. Series are rebased to 1 in the first observation. Types of break: Model 5 with two breaks (Banerjee and Carrion-i Silvestre, 2015).***devia se escrever o modelo em vez de model 5

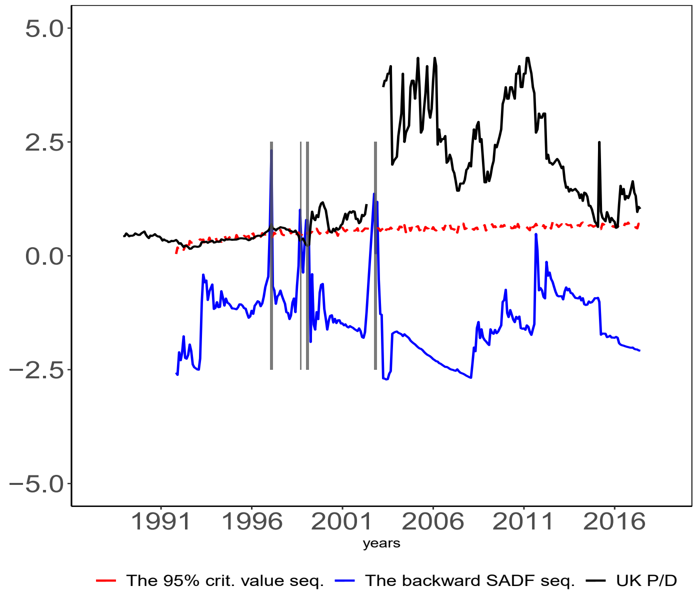


Figure 8. Date-stamping bubble periods in the price-dividend ratio for UK *explorers & producers* subsector: the GSADF test. The vertical grey areas correspond to the bubble or collapse periods.

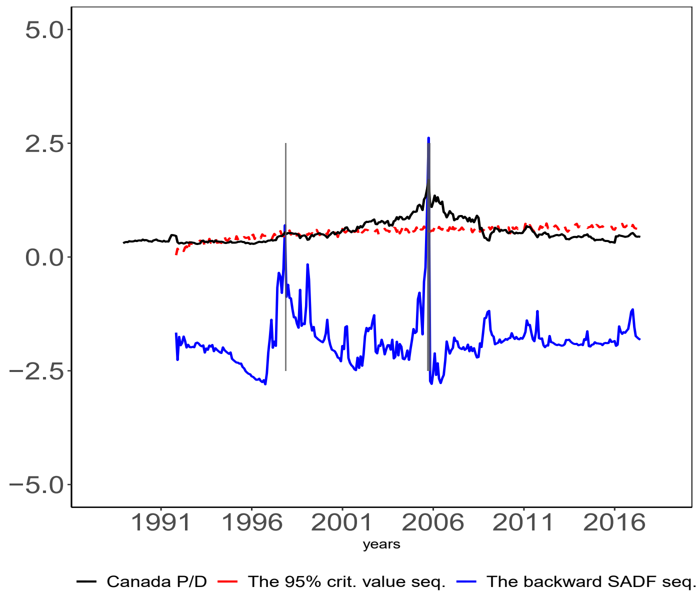


Figure 9. Date-stamping bubble periods in the price-dividend ratio for Canada *integrated* subsector: the GSADF test. The vertical grey areas correspond to the bubble or collapse periods.

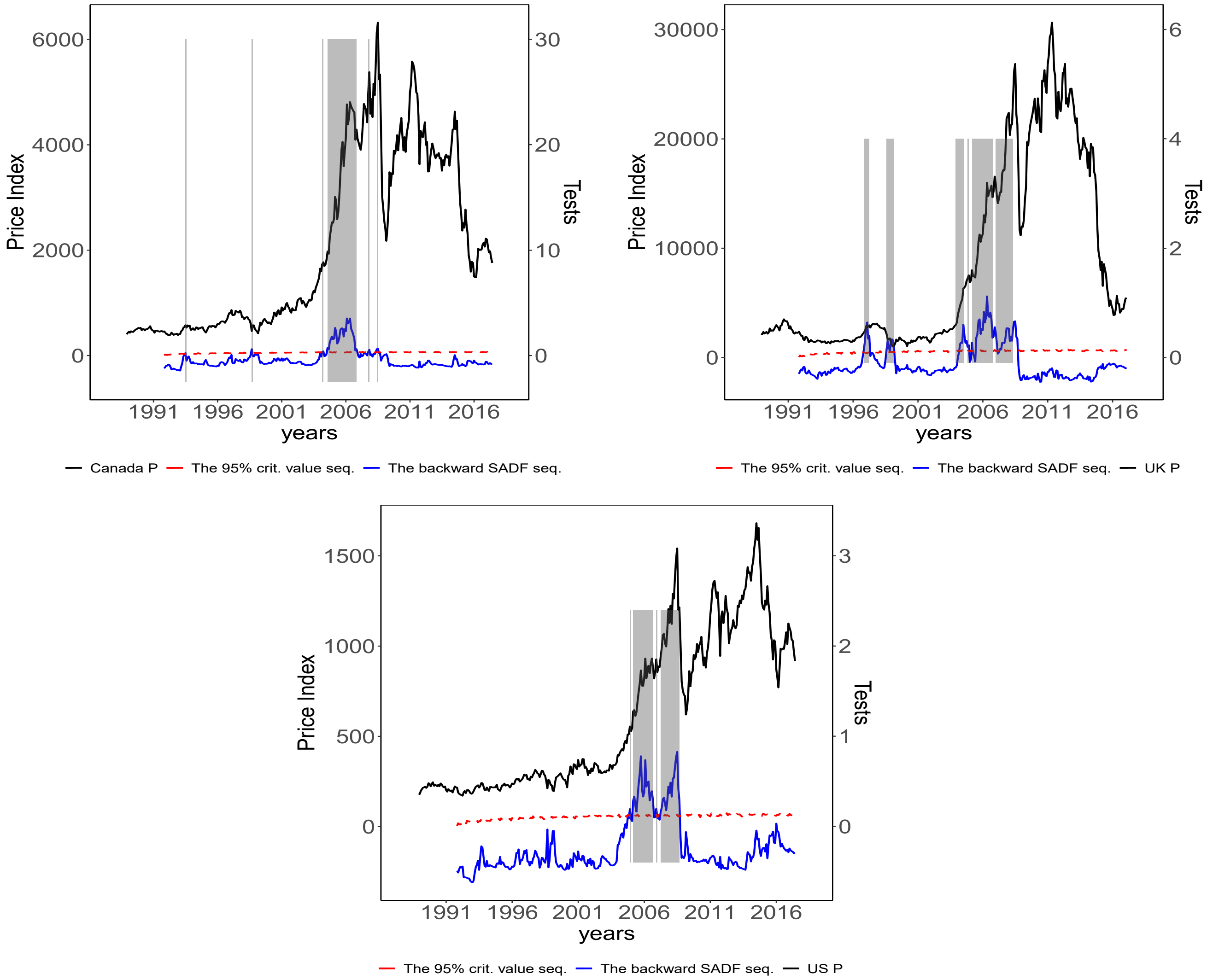


Figure 10. Date-stamping bubble periods in the prices indexes for the *explorers & producers* subsector: the GSADF test. The vertical grey areas correspond to the bubble or collapse periods.

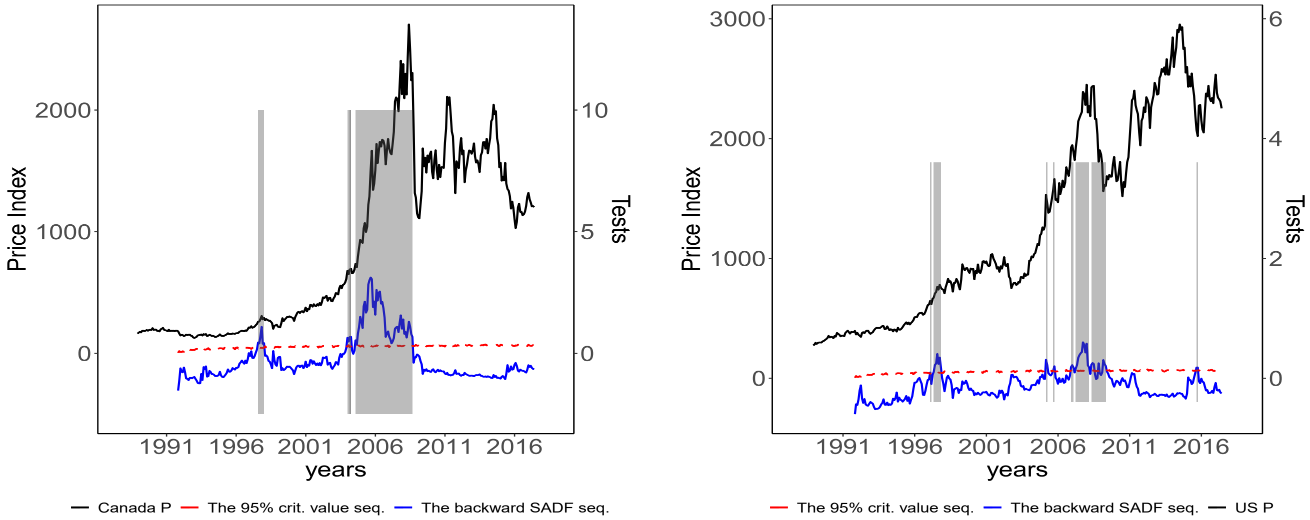


Figure 11. Date-stamping bubble periods in the prices indexes for the *integrated* subsector, Canada and the U.S.: the GSADF test. The vertical grey areas correspond to the bubble or collapse periods.

Appendix

Appendix A: The Present Value Model

The present value model is a cornerstone of the finance theory and it will be our framework to analyse changes in stock price.

Let us define the variables P_{it} as the real price of sector/firm i during period t, D_{it} is the real dividend paid of sector/firm i during period t. The lowercase letters represent logs of the corresponding uppercase letters: $p_{it} = ln(P_{it})$ is the natural log of the price, and $dp_{it} = ln(D_{it})$ is the natural log dividend-to-price ratio.

We follow closely the approach Sarno and Taylor (1999) and McMillan (2010). Given the assumptions of rational expectations, risk-neutrality and market equilibrium the movement of share prices over time is given by the present value of future cash flows:

$$P_t = \delta(E_t P_{t+1} + E_t D_{t+1}), \tag{13}$$

where P_t is the stock price at time t, D_{t+1} is the dividend paid on the stock in time period t, δ = 1/(1 + R) is the discount factor (with R the constant required rate of return, or discount rate), while E_t is the expectations operator conditioned on information up to t. A solution to Equation 13 is provided by imposing the transversality condition and substituting recursively for all future prices, this relates the stock price to discounted expected future dividends, with the discount rate constant and equal to the required rate of return:

$$P_t = \sum_{i=1}^{\propto} \delta^i E_t D_{t+i}.$$

This formula represents the fundamental value for prices, and ensures a unique price. Following Campbell and Shiller (1987), if the present value model hold then stock prices and dividends will be cointegrated, with a cointegrating vector (1, 1/R), that is

$$P_t - R^{-1}D_t = R^{-1}E_t\left[\sum_{i=0}^{\infty}\left(\frac{1}{1+R}\right)^{-i}\Delta D_{t+1+i}\right].$$

Campbell and Shiller (1988b,a) have provided the well-known log-linear approximation

$$p_t = \frac{k}{1-\rho} + E_t\left[(1-\rho)\sum_{i=0}^{\infty}\rho^i d_{t+1+i} - \sum_{i=0}^{\infty}\rho^i r_{t+1+i}\right], \tag{14}$$

where the lower case letters p, d, r denotes the logarithms of prices, dividends and the discount rate, respectively. The symbols ρ and k denote linearisation parameters, which are $\rho = 1/[exp(d-p)]$ and $k = -log(\rho) - (1-\rho)log(1/\rho - 1)$. We can re-write (Equation 14 in terms of the log dividend-price ratio (dividend yield):

$$d_t - p_t = \frac{k}{1-\rho} + E_t\left[\sum_{i=0}^{\infty}\rho^i(-\Delta d_{t+1+i} + r_{t+1+i})\right] \tag{15}$$

This relationship states that the dividend-price ratio will be stationary provided that changes in dividends and the discount rate are stationary, and that implicitly log prices and log dividends are cointegrated with a cointegrating vector of (1,-1). The statistical analysis of Equation 15 therefore involves only testing the stationarity of the log price-dividend ratio and does not require estimation of the (unknown) cointegrating parameter. Intuitively, Equation 15 states that if dividends are expected to grow, then current prices will be higher and the dividend yield will be low, while if the future discount rate is expected to be high, then current prices will be low and the dividend yield will be high.

Appendix B: Stationarity of oil prices

Since the price of crude Brent oil is a single time series, we cannot test for non-stationary using the same unit root test. Therefore, for oil unit root test we use another method introduced by Ng and Perron (2001). The null hypothesis of the unit root test is that of non-stationary. The tests statistics MZ_{α}^{GLS} and MZ_{t}^{GLS} in Table B.1 indicate that we cannot reject the null hypothesis of unit root while the test statistics MP_{t}^{GLS} says the opposite. We conclude that the oil price is non-stationary.

Table B.1
Unit root test results for oil price

This table presents the results of the unit root tests of Ng and Perron (2001).

Variable	MZ_{α}^{GLS}	MZ_{t}^{GLS}	MP_{t}^{GLS}	Breaks
oil	-30.634	-3.891	14.573*	August 1992 July 1997 May 2001 July 2006 July 2012

Figure B.1. Oil prices in US dollars and break dates (vertical lines) obtained with the unit root test by Ng and Perron (2001).

Appendix C: Additional Tables and Figures

Table C.1
Variable Definition

This table describes variables used in this study.

Variables	Definition
explorers & producers	Dummy variable that indicates if the subsector/ firm is from subsector Oil Exploration and Production using Global Industry Classification Standards. MNEMONIC is OILEP. Source: Datastream
integrated	Dummy variable that indicates if the subsector/ firm is from subsector Integration using Global Industry Classification Standards. MNEMONIC is OILIN. Source: Datastream
p	Logarithm of the price index of subsectors or Logarithm of prices of firms. Monthly prices in US dollars from June 1990 to May 2017. Nominal prices are deflated with US CPI Seasonally adjusted. Source: Datastream.
d	Logarithm of the dividends per share of subsectors or firms. Monthly frequency in US dollars from June 1990 to May 2017. Nominal prices are deflated with US CPI Seasonally adjusted. Source: Datastream.
dy	Logarithm of the dividend yield of subsectors or firms. Monthly frequency in US dollars from June 1990 to May 2017. Source: Datastream.
market	Logarithm of price index of the stock market index. MNEMONIC is TOTMK. Monthly prices from June 1990 to May 2017. Source: Datastream.
oil	Logarithm of the price of Brent oil in US dollars per barrel (U$/BBL). Monthly prices in US dollars from June 1990 to May 2017. Source: Datastream.
roe	Return on equity of sector or firms (demeaned). Monthly returns in US dollars from June 1990 to May 2017. Source: Datastream.
rir	real interest rate (demeaned). Monthly returns in US dollars from June 1990 to May 2017. Source: Datastream.
rer	real exchange rate (demeaned). returns from June 1990 to May 2017. Source: Datastream.

Table C.2
Sample of Firms

This table presents the firms in the sample. Firms belong to two subsectors Producers& Explorers and Integrated.

Firm Name	Subsector	Country
ANADARKO PETROLEUM	Explorers & Producers	US
APACHE	Explorers & Producers	US
BP	Integrated	UK
CABOT OIL & GAS 'A'	Explorers & Producers	US
CHEVRON	Integrated	US
CONOCOPHILLIPS	Integrated	US
ENCANA	Explorers & Producers	Canada
ENERPLUS	Explorers & Producers	Canada
EOG RES.	Explorers & Producers	US
EQT	Explorers & Producers	US
EXXON MOBIL	Integrated	US
HESS	Integrated	US
HOLLYFRONTIER	Explorers & Producers	US
IMPERIAL OIL	Integrated	Canada
MURPHY OIL	Explorers & Producers	US
NOBLE ENERGY	Explorers & Producers	US
OCCIDENTAL PTL.	Explorers & Producers	US
ROYAL DUTCH SHELL B	Integrated	UK
SANAI OIL	Explorers & Producers	Japan
SHOWA SHELL SEKIYU	Integrated	Japan
VALERO ENERGY	Explorers & Producers	US

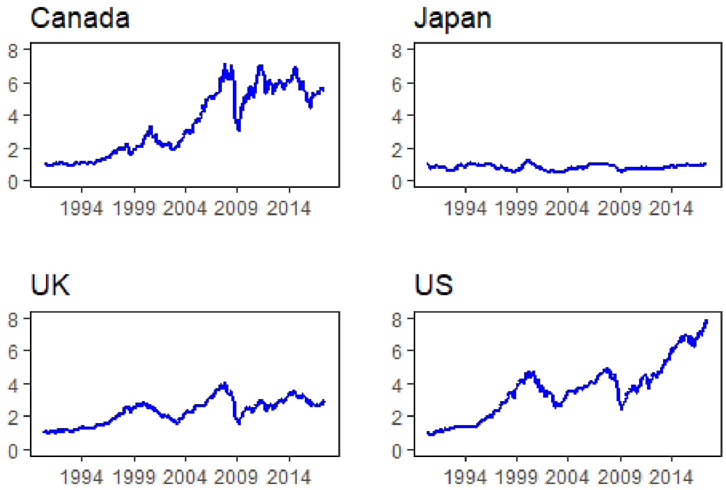


Figure C.1. Stock market prices indexes. All series are rebased to 1 in the beginning of the time period.

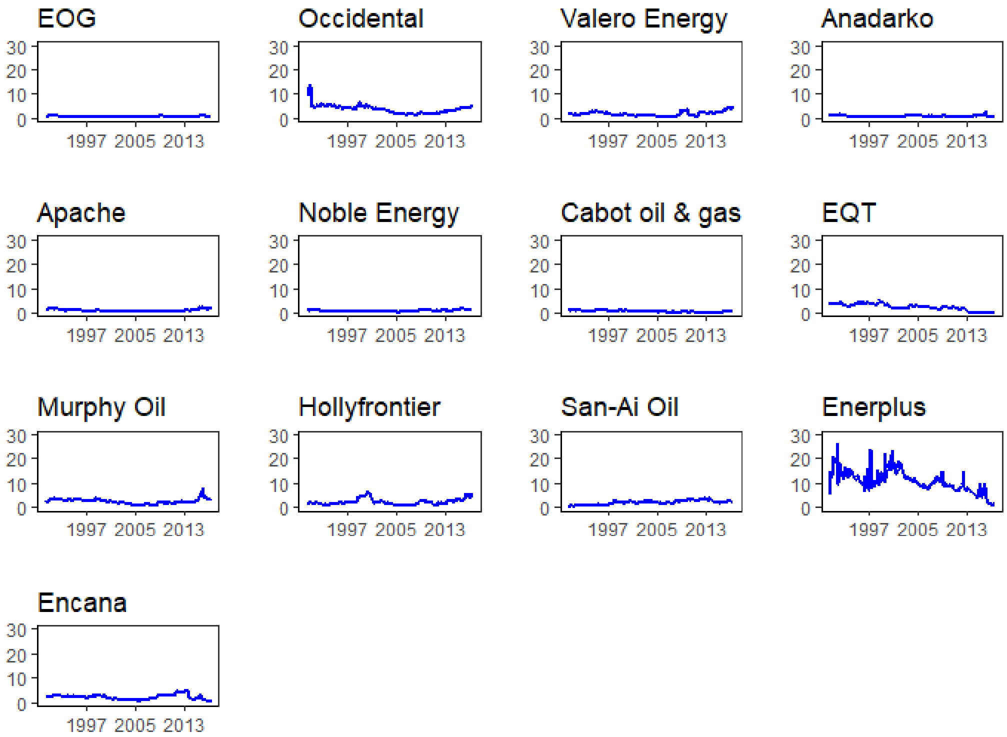


Figure C.2. Dividend Yield (in percentage) for the sample of firms of the subsector *explorers & producers*.

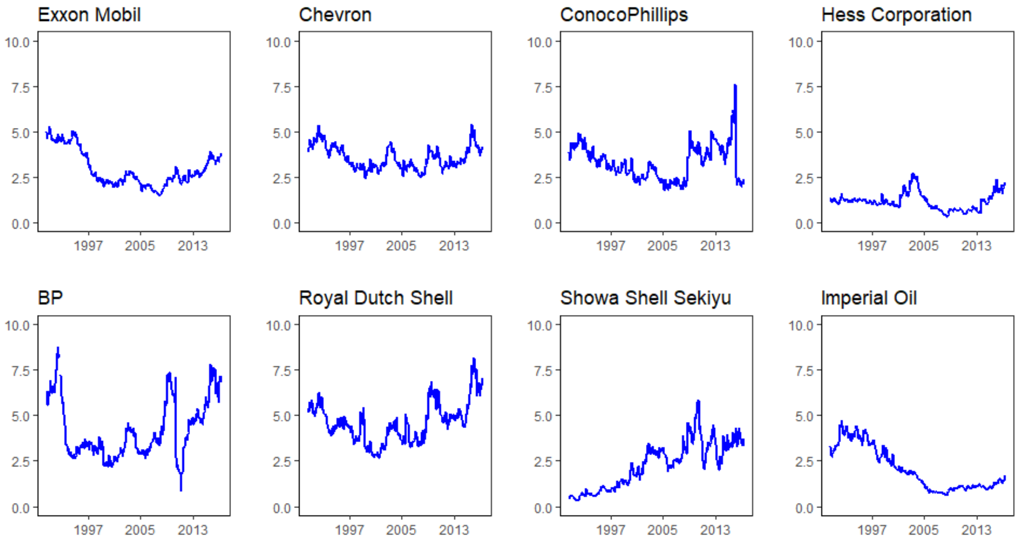


Figure C.3. Dividend Yield (in percentage) for the sample of firms of the subsector *integrated*.

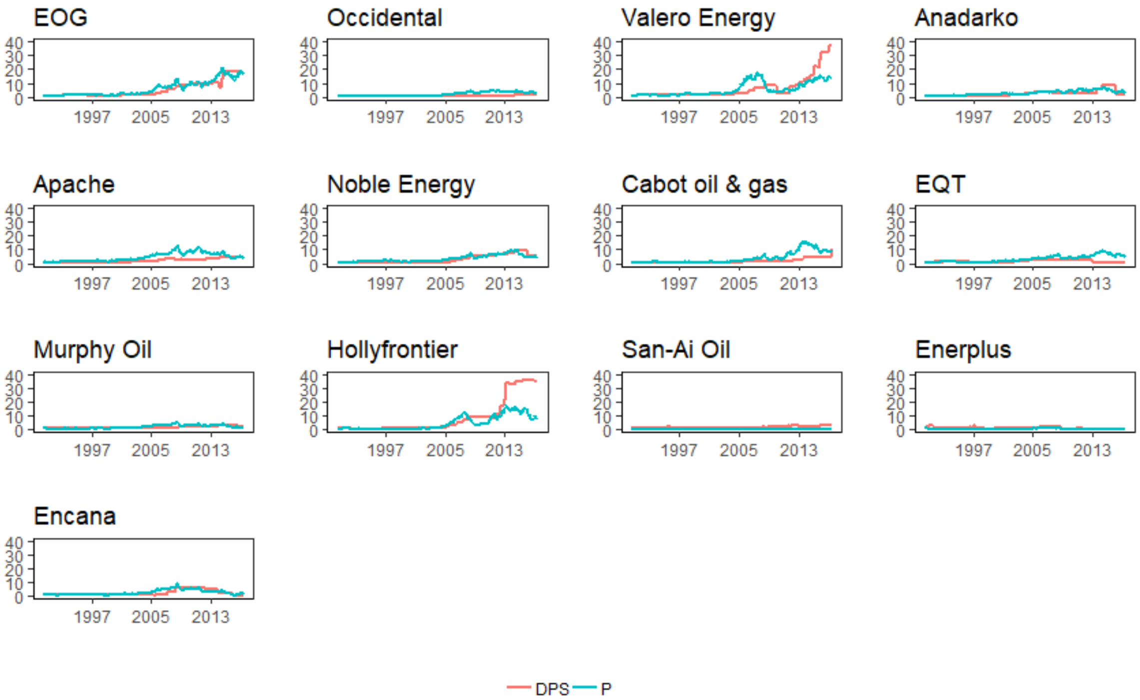


Figure C.4. Logarithm of price indexes and dividends for firms in the subsector *explorers & producers*. Series are rebased to 1 in the first observation.

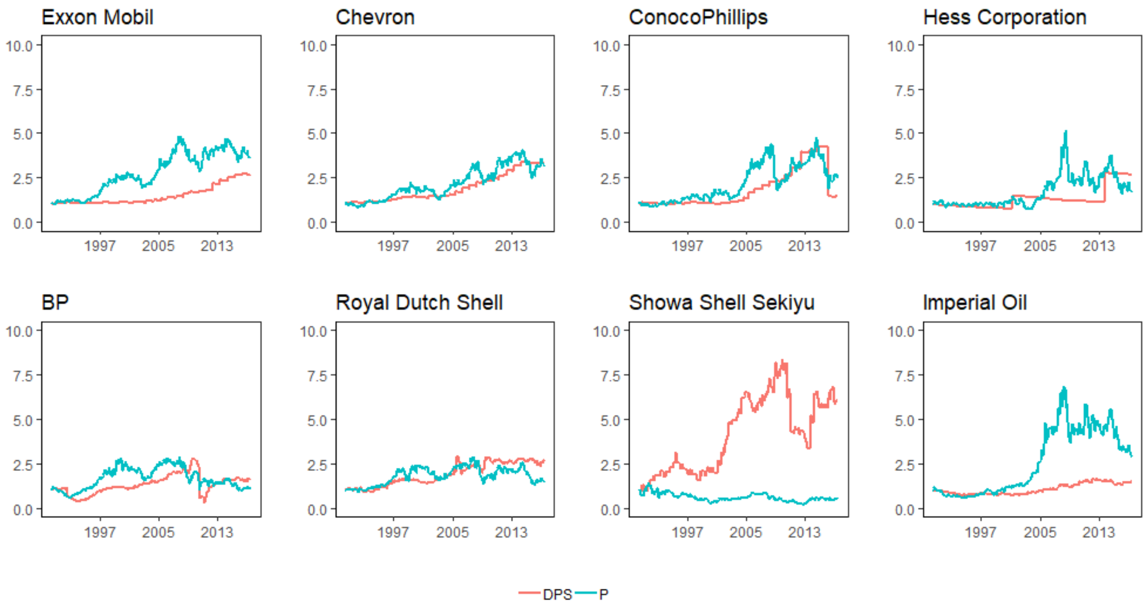


Figure C.5. Logarithm of price indexes and dividends for firms in the subsector *integrated*. Series are rebased to 1 in the first observation.

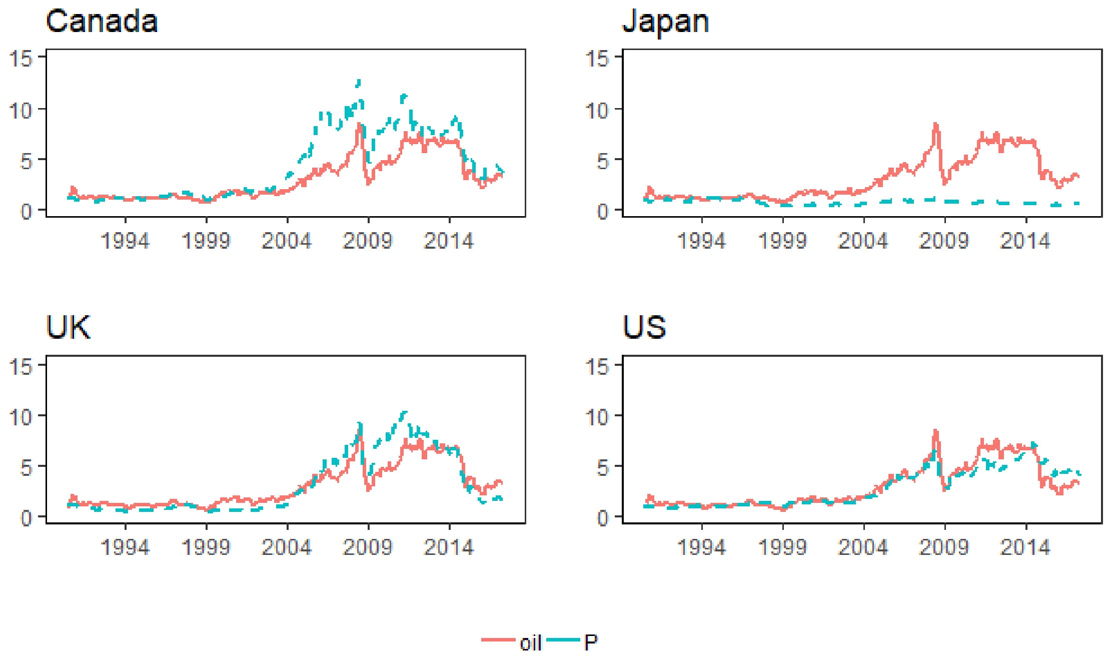


Figure C.6. Logarithms of price indexes for the subsector *explorers* & *producers* and oil prices. Series are rebased to 1 in the first observation.

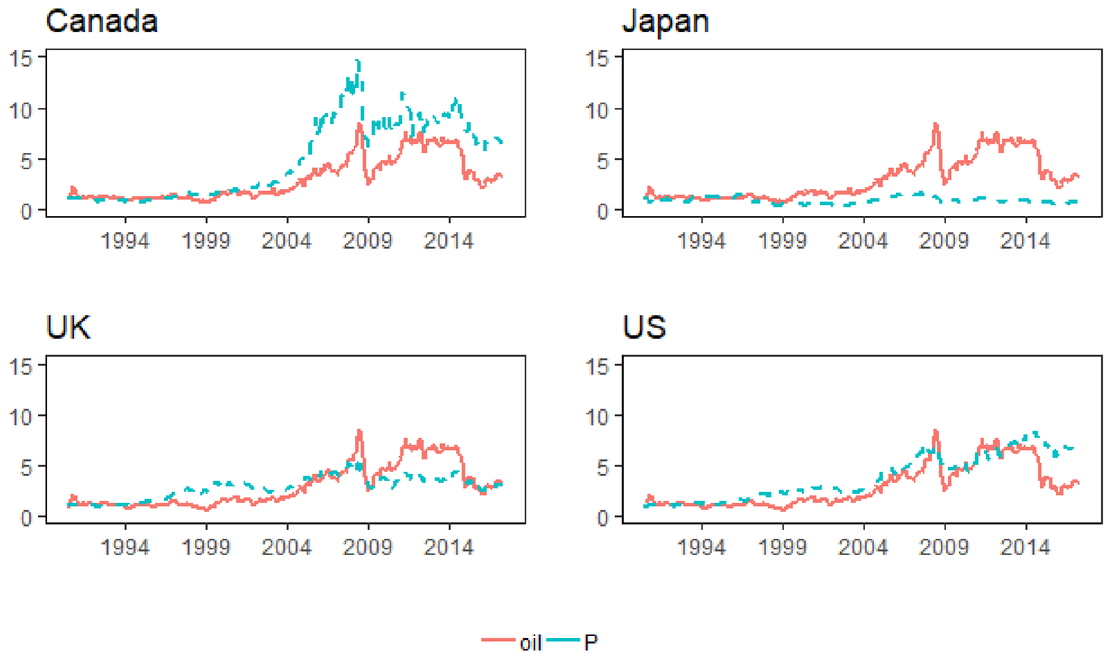


Figure C.7. Logarithms of price indexes for the subsector *integrated* and oil prices. Series are rebased to 1 in the first observation.

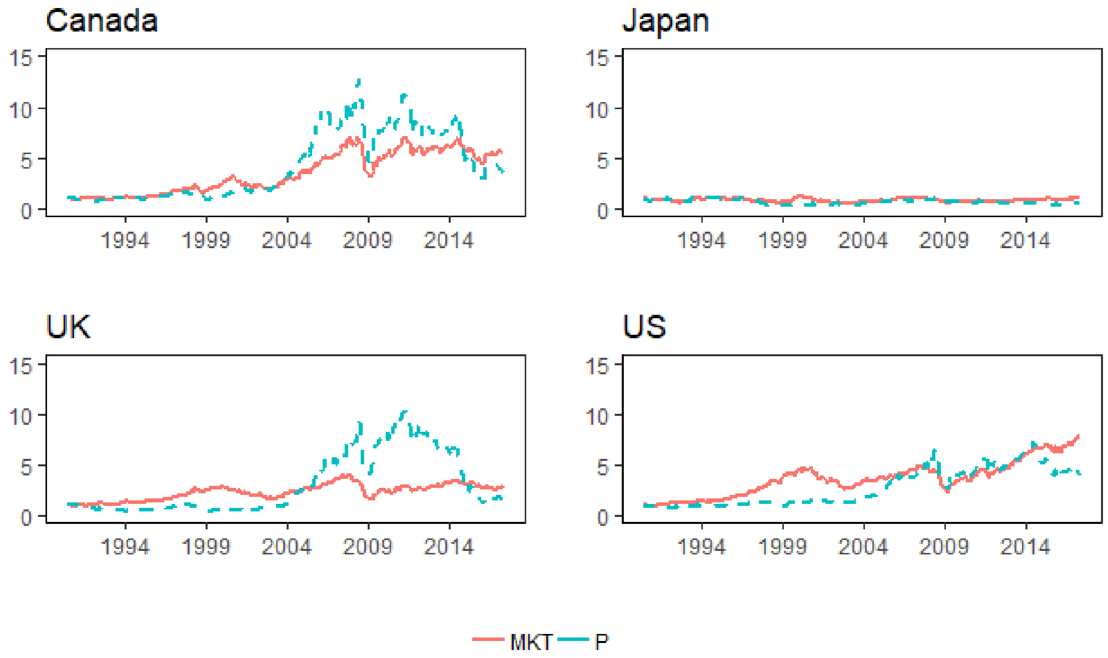


Figure C.8. Logarithms of price indexes for the subsector *explorers & producers* and stock market index. Series are rebased to 1 in the first observation.

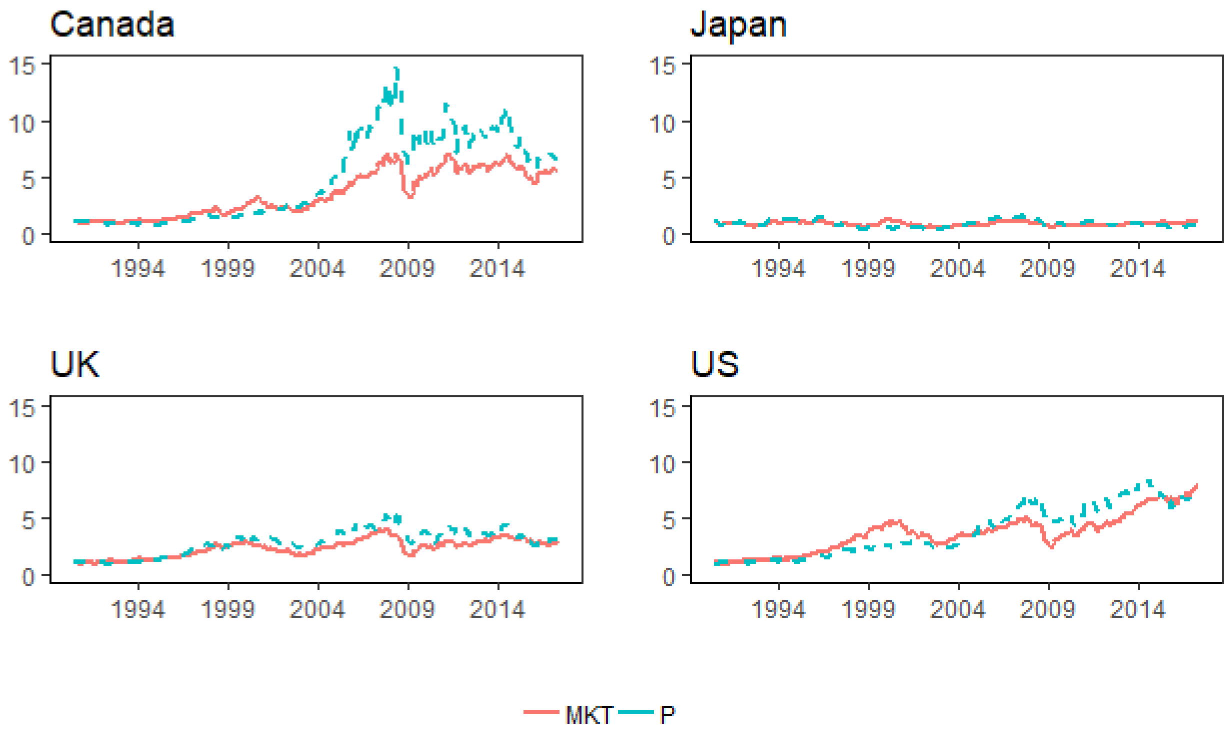


Figure C.9. Logarithms of price indexes for the subsector *integrated* and stock market index. Series are rebased to 1 in the first observation.

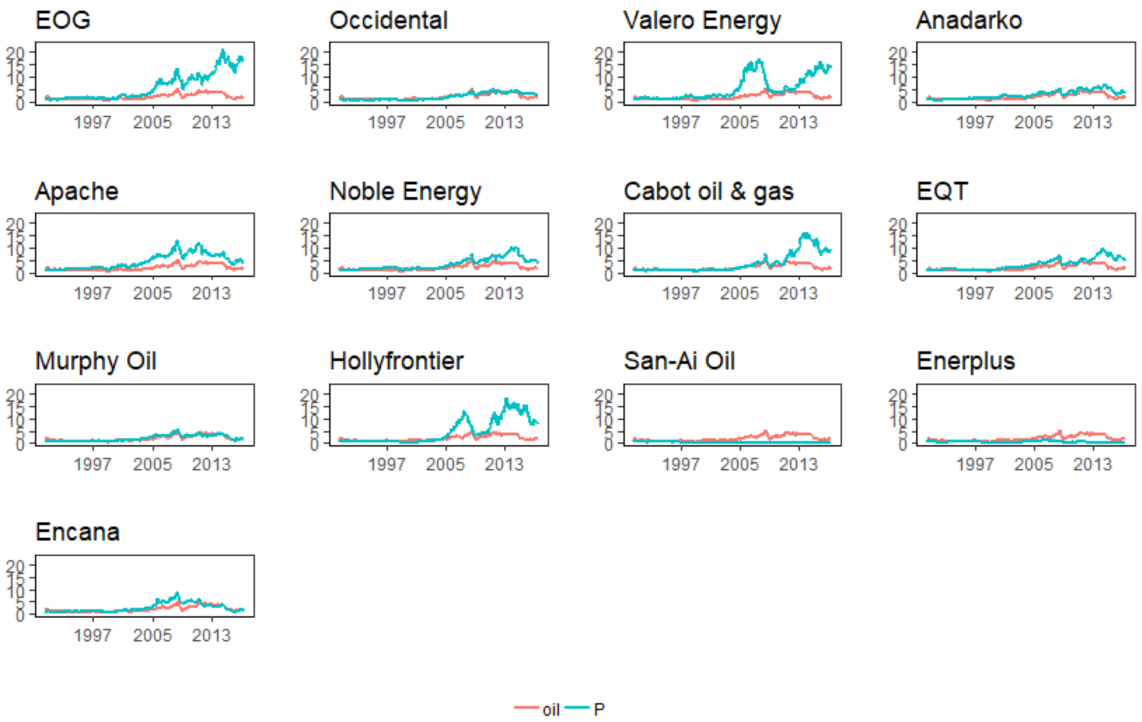


Figure C.10. Log of prices for firms in the subsector *explorers & producers* and log of oil prices. Time on *x-axis*. *y-axis* are prices in logs. The first observations are rebased to one.

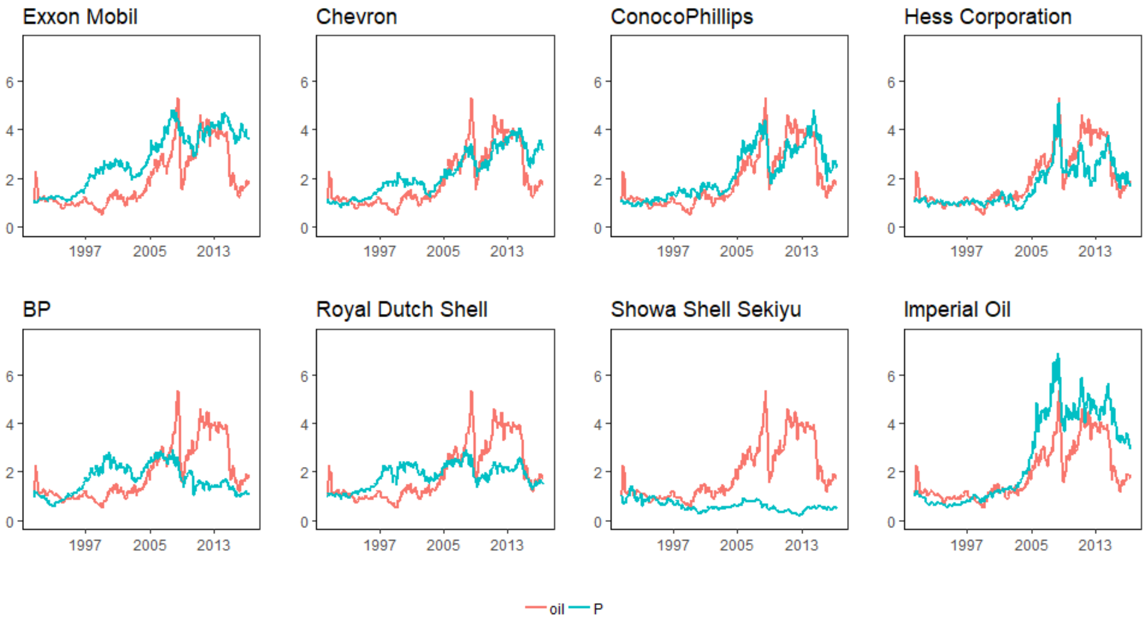


Figure C.11. Log of prices for firms in the subsector *integrated* and log of oil prices. Time on *x-axis*. *y-axis* are prices in logs. The first observations are rebased to one.

Appendix D: VAR analysis

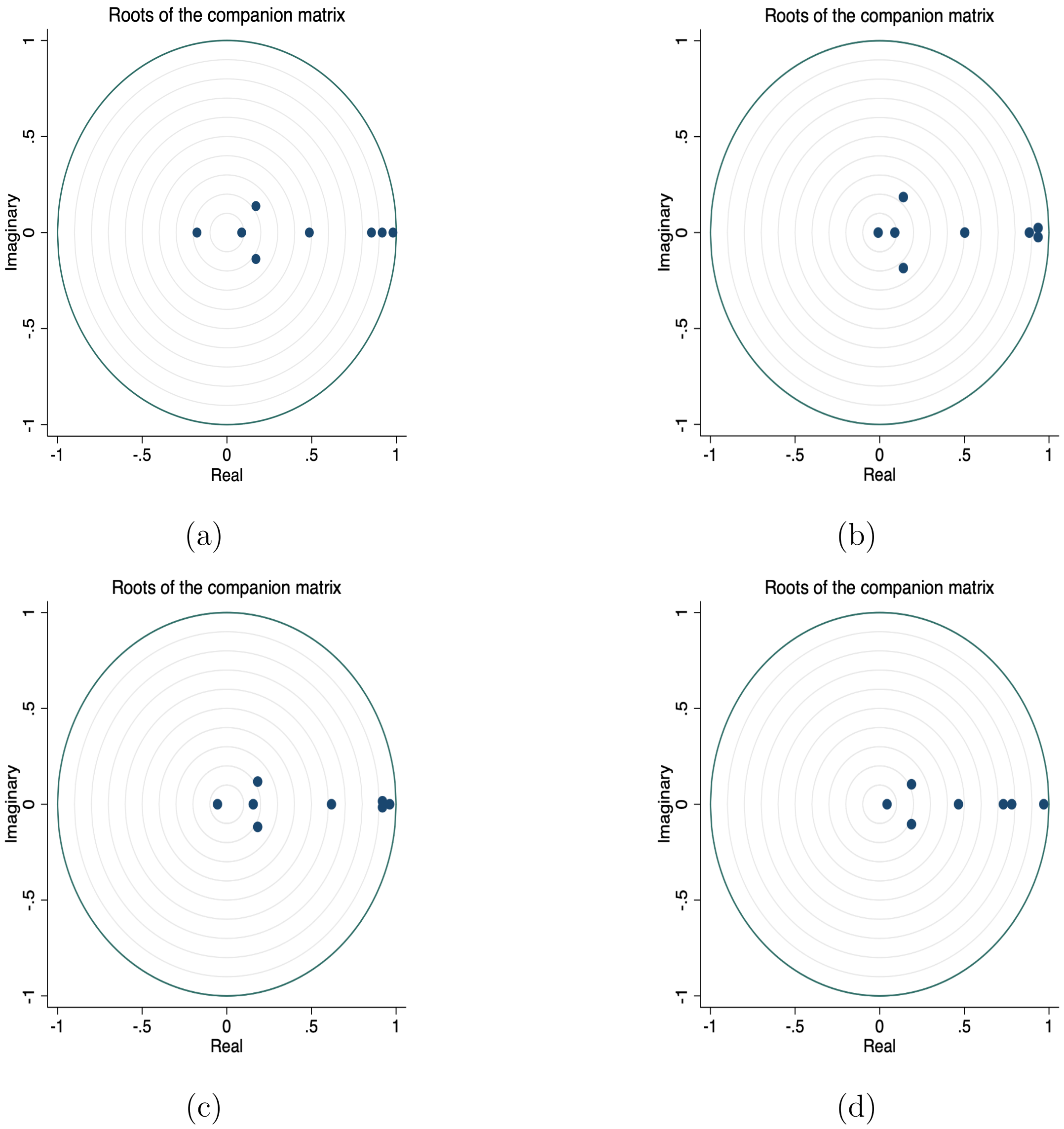


Figure C.12. Stability of VARs for the *explorers* & *producers* subsector: (a) Canada, (b) Japan, (c) UK and (d) US.

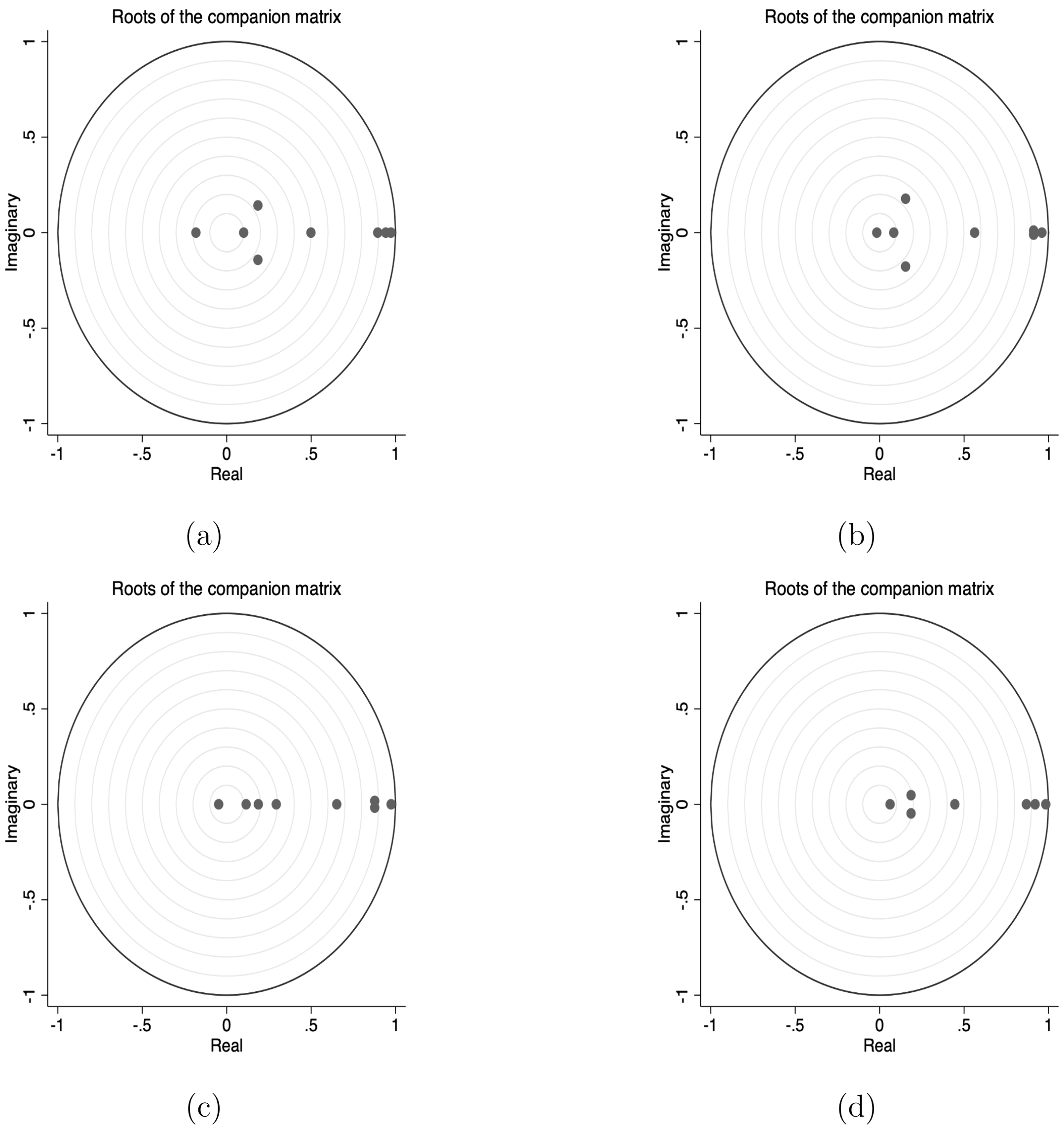


Figure C.13. Stability of VARs for the *integrated* subsector: (a) Canada, (b) Japan, (c) UK and (d) US.

Table C.3
VAR estimation (Canada): *explorers* & *producers* and *integrated* subsectors

	dy_{it}	roe^{+}_{it}	roe^{-}_{it}	irr^{+}_{it}	irr^{-}_{it}	$market_{it}$	oil_{it}	rer_{it}
				explorers & producers				
Const.	-0.040	0.589**	-0.547**	0.001***	-0.001***	0.003	0.029**	0.003
	(0.215)	(0.015)	(0.040)	(0.000)	(0.000)	(0.679)	(0.011)	(0.286)
dy_{t-1}	0.970***	-0.010	-0.071	0.000	0.000***	0.001	0.004	0.000
	(0.000)	(0.910)	(0.463)	(0.298)	(0.000)	(0.662)	(0.365)	(0.790)
roe^{+}_{t-1}	0.003	0.865***	0.025	0.000	0.000	0.000	-0.003	0.000
	(0.496)	(0.000)	(0.464)	(0.318)	(0.755)	(0.950)	(0.026)	(0.902)
roe^{-}_{t-1}	0.001	0.036	0.883***	0.000**	0.000	0.000	0.001	0.000
	(0.845)	(0.161)	(0.000)	(0.012)	(0.670)	(0.847)	(0.577)	(0.317)
irr^{+}_{t-1}	4.885	10.130	89.890	0.453***	0.096**	-0.829	-5.676*	-0.893
	(0.568)	(0.875)	(0.207)	(0.000)	(0.034)	(0.634)	(0.062)	(0.217)
irr^{-}_{t-1}	-23.565**	12.716	-3.623	-0.018	0.220***	1.367	8.860**	0.857
	(0.019)	(0.866)	(0.965)	(0.735)	0.000)	(0.503)	(0.013)	(0.313)
$market_{t-1}$	-0.279	-1.315	2.146	-0.012***	-0.005**	0.180**	0.165	-0.060*
	(0.503)	(0.675)	(0.536)	(0.000)	(0.016)	(0.034)	(0.265)	(0.091)
oil_{t-1}	-0.257	-2.592**	0.687	-0.006***	-0.005***	0.026	0.095	-0.034**
	(0.124)	(0.039)	(0.621)	0.000)	0.000)	(0.437)	(0.111)	(0.017)
rer_{t-1}	-0.483	-10.986	12.208	-0.016***	-0.005	0.236	0.007	-0.180**
	(0.626)	(0.140)	(0.138)	(0.004)	(0.371)	(0.242)	(0.985)	(0.031)
				integrated				
Const.	-0.010	0.424***	-0.112	0.001***	-0.001***	0.000	0.024**	0.002
	(0.565)	(0.006)	(0.526)	(0.000)	(0.000)	(0.983)	(0.018)	(0.301)
dy_{t-1}	0.970***	-0.082	-0.036	0.000	0.001***	-0.005	-0.019**	0.004**
	(0.000)	(0.510)	(0.800)	(0.203)	(0.000)	(0.319)	(0.019)	(0.025)
roe^{+}_{t-1}	-0.002	0.912***	0.014	0.000	0.000	0.000	-0.004**	0.000
	(0.483)	(0.000)	(0.632)	(0.981)	(0.120)	(0.944)	(0.028)	(0.756)
roe^{-}_{t-1}	0.002	0.029	0.924***	0.000*	0.000	-0.001	-0.001	0.000
	(0.302)	(0.140)	(0.000)	(0.077)	(0.366)	(0.248)	(0.446)	(0.126)
irr^{+}_{t-1}	10.026*	-93.849**	-36.915	0.454***	0.034	-0.312	-4.622	-1.001
	(0.052)	(0.039)	(0.477)	(0.000)	(0.448)	(0.854)	(0.117)	(0.153)
irr^{-}_{t-1}	-6.003	-6.044	48.868	-0.022	0.271***	1.920	10.822***	0.250
	(0.320)	(0.910)	(0.422)	(0.680)	(0.000)	(0.334)	(0.002)	(0.761)
$market_{t-1}$	0.077	-1.143	1.716	-0.012***	-0.004*	0.187**	0.156	-0.060*
	(0.763)	(0.611)	(0.503)	(0.000)	(0.050)	(0.026)	(0.285)	(0.083)
oil_{t-1}	-0.033	-2.029**	-0.028	-0.005***	-0.004***	0.022	0.079	-0.031**
	(0.749)	(0.026)	(0.979)	(0.000)	0.000)	(0.511)	(0.178)	(0.025)
rer_{t-1}	-0.234	-6.701	9.927	-0.016***	-0.005	0.274	0.053	-0.204**
	(0.702)	(0.215)	(0.107)	(0.003)	(0.345)	(0.173)	(0.879)	(0.014)

Note: ***,**,* means significant at 1%, 5% and 1%, respectively. pvalues between parentheses.

Table C.4
VAR estimation (Japan): *explorers* & *producers* and *integrated* subsectors

	dy_{it}	roe^{+}_{it}	roe^{-}_{it}	irr^{+}_{it}	irr^{-}_{it}	$market_{it}$	oil_{it}	rer_{it}
				explorers & producers				
Const.	0.037*	0.084	-0.138*	0.001***	-0.001***	-0.004	0.015	0.000
	(0.061)	(0.139)	(0.086)	(0.000)	(0.000)	(0.586)	(0.140)	(0.925)
dy_{t-1}	0.938***	0.094*	-0.019	0.000***	0.000	0.019***	0.001	-0.001
	(0.000)	(0.075)	(0.797)	(0.009)	(0.634)	(0.002)	(0.912)	(0.729)
roe^{+}_{t-1}	-0.014	0.913***	0.061*	0.000**	0.000***	0.003	0.009*	0.000
	(0.107)	(0.000)	(0.085)	(0.025)	(0.001)	(0.327)	(0.054)	(0.943)
roe^{-}_{t-1}	0.001	0.012	0.895***	0.000	0.000	0.000	0.004	0.000
	(0.925)	(0.504)	(0.000)	(0.219)	(0.879)	(0.890)	(0.264)	(0.862)
irr^{+}_{t-1}	-11.524**	7.484	8.479	0.473***	0.011	3.108	-7.420**	-1.223
	(0.049)	(0.654)	(0.720)	(0.000)	(0.798)	(0.102)	(0.013)	(0.217)
irr^{-}_{t-1}	4.167	-17.722	29.823	-0.085	0.158***	2.296	11.763***	-1.186
	(0.562)	(0.388)	(0.305)	(0.135)	(0.004)	(0.326)	(0.001)	(0.330)
$market_{t-1}$	-0.051	-0.218	-1.441*	-0.004***	-0.002*	0.059	0.179*	0.037
	(0.781)	(0.678)	(0.053)	(0.003)	(0.074)	(0.325)	(0.056)	(0.241)
oil_{t-1}	-0.094	0.037	-0.487	-0.007***	-0.006***	0.080**	0.092	-0.034
	(0.404)	(0.910)	(0.288)	(0.000)	(0.000)	(0.030)	(0.111)	(0.079)
rer_{t-1}	0.067	-0.234	-1.791	-0.005	-0.004	0.040	0.127	0.090
	(0.852)	(0.819)	(0.216)	(0.072)	(0.123)	(0.733)	(0.488)	(0.138)
				integrated				
Const.	0.002	0.450**	0.004	0.000**	-0.001***	-0.002	0.023**	0.001
	(0.944)	(0.020)	(0.986)	(0.010)	(0.000)	(0.764)	(0.020)	(0.847)
dy_{t-1}	0.957***	-0.064	-0.045	0.000*	0.000*	0.007*	-0.004	0.002
	(0.000)	(0.594)	(0.741)	(0.094)	(0.092)	(0.078)	(0.506)	(0.440)
roe^{+}_{t-1}	0.000	0.912***	-0.010	0.000	0.000	0.000	0.000	0.000
	(0.909)	(0.000)	(0.737)	(0.547)	(0.454)	(0.840)	(0.702)	(0.480)
roe^{-}_{t-1}	-0.001	0.016	0.917***	0.000	0.000**	-0.001	0.001	0.000
	(0.761)	(0.476)	(0.000)	(0.826)	(0.018)	(0.426)	(0.441)	(0.579)
irr^{+}_{t-1}	-11.601	-75.454	-173.411***	0.506***	0.028	2.035	-7.915***	-1.040
	(0.122)	(0.195)	(0.009)	(0.000)	(0.519)	(0.276)	(0.007)	(0.279)
irr^{-}_{t-1}	-17.788	43.691	63.162	-0.073	0.180***	2.078	9.853***	-1.129
	(0.057)	(0.547)	(0.446)	(0.201)	(0.001)	(0.372)	(0.007)	(0.345)
$market_{t-1}$	-0.282	-1.252	-4.316**	-0.004***	-0.003*	0.059	0.181*	0.036
	(0.248)	(0.508)	(0.046)	(0.003)	(0.059)	(0.327)	(0.057)	(0.249)
oil_{t-1}	-0.274*	-0.367	-0.869	-0.007***	-0.006***	0.076**	0.103*	-0.031
	(0.066)	(0.750)	(0.509)	(0.000)	(0.000)	(0.040)	(0.076)	(0.103)
rer_{t-1}	-1.289***	-6.483*	-10.621**	-0.004	-0.003	0.023	0.113	0.085
	(0.007)	(0.079)	(0.012)	(0.134)	(0.248)	(0.845)	(0.545)	(0.164)

Note: ***,**,* means significant at 1%, 5% and 1%, respectively. pvalues between parentheses.

Table C.5
VAR estimation (UK): *explorers & producers* and *integrated* subsectors

	dy_{it}	roe^{+}_{it}	roe^{-}_{it}	irr^{+}_{it}	irr^{-}_{it}	$market_{it}$	oil_{it}	rer_{it}
				explorers & producers				
Const.	0.011	0.811	-0.184	0.001***	-0.001***	0.007	0.014	-0.007**
	(0.701)	(0.123)	(0.711)	(0.000)	(0.000)	(0.186)	(0.160)	(0.017)
dy_{t-1}	0.978***	-0.107	-0.366	0.000***	0.000***	0.001	-0.004	0.002
	(0.000)	(0.659)	(0.111)	(0.003)	(0.000)	(0.828)	(0.403)	(0.197)
roe^{+}_{t-1}	-0.002	0.917***	0.009	0.000*	0.000	0.000	0.000	0.000
	(0.308)	(0.000)	(0.729)	(0.052)	(0.906)	(0.280)	(0.898)	(0.306)
roe^{-}_{t-1}	0.004**	-0.027	0.907***	0.000	0.000	0.000	-0.001	0.000*
	(0.014)	(0.303)	(0.000)	(0.332)	(0.232)	(0.462)	(0.107)	(0.063)
irr^{+}_{t-1}	7.985	-94.769	-63.620	0.579***	0.046	-1.615	-5.936**	0.836
	(0.321)	(0.505)	(0.636)	(0.000)	(0.304)	(0.261)	(0.030)	(0.285)
irr^{-}_{t-1}	-6.090	158.740	275.118*	-0.023	0.328***	1.072	9.201***	-1.837**
	(0.513)	(0.336)	(0.077)	(0.632)	(0.000)	(0.520)	(0.004)	(0.043)
$market_{t-1}$	-0.020	12.414*	2.758	-0.010***	-0.004	0.109	0.324	-0.058
	(0.956)	(0.051)	(0.646)	(0.000)	(0.043)	(0.089)	(0.008)	(0.098)
oil_{t-1}	-0.052	0.151	5.156*	-0.006***	-0.004***	-0.007	0.080	-0.048***
	(0.754)	(0.959)	(0.064)	(0.000)	(0.000)	(0.808)	(0.157)	(0.003)
rer_{t-1}	-0.300	14.386	11.785	-0.012***	-0.003	0.057	-0.086	-0.012
	(0.645)	(0.213)	(0.280)	(0.000)	(0.398)	(0.624)	(0.698)	(0.845)
				integrated				
Const.	-0.052	0.271	-0.387*	0.001***	-0.001***	0.003	0.013	-0.006*
	(0.204)	(0.264)	(0.062)	(0.001)	(0.000)	(0.598)	(0.292)	(0.074)
dy_{t-1}	0.969***	-0.098	-0.109	0.000***	0.000	0.002	-0.001	-0.001
	(0.000)	(0.302)	(0.180)	(0.009)	(0.113)	(0.357)	(0.900)	(0.652)
roe^{+}_{t-1}	0.002	0.893***	0.043*	0.000	0.000	0.000	0.000	0.000
	(0.716)	(0.000)	(0.090)	(0.310)	(0.303)	(0.951)	(0.881)	(0.866)
roe^{-}_{t-1}	0.002	-0.008	0.882***	0.000	0.000	-0.001	-0.002	-0.001
	(0.737)	(0.814)	(0.000)	(0.358)	(0.634)	(0.495)	(0.270)	(0.148)
irr^{+}_{t-1}	14.737	-25.133	-64.215	0.580***	0.112**	-1.689	-6.189**	1.022
	(0.124)	(0.656)	(0.183)	(0.000)	(0.019)	(0.247)	(0.027)	(0.201)
irr^{-}_{t-1}	-24.370**	-47.158	7.492	0.049	0.419***	1.670	8.031***	-1.454*
	(0.018)	(0.436)	(0.885)	(0.292)	(0.000)	(0.286)	(0.007)	(0.090)
$market_{t-1}$	0.088	1.163	2.336	-0.009***	-0.004*	0.108*	0.313**	-0.063*
	(0.835)	(0.640)	(0.272)	(0.000)	(0.063)	(0.093)	(0.011)	(0.076)
oil_{t-1}	0.400**	-0.774	1.193	-0.005***	-0.004***	-0.009	0.081	-0.047***
	(0.041)	(0.501)	(0.226)	(0.000)	(0.000)	(0.768)	(0.157)	(0.004)
rer_{t-1}	0.376	-6.032	4.667	-0.012***	-0.003	0.038	-0.080	-0.008
	(0.623)	(0.180)	(0.225)	(0.001)	(0.417)	(0.741)	(0.719)	(0.902)

Note: ***,**,* means significant at 1%, 5% and 1%, respectively. pvalues between parentheses.

Table C.6
VAR estimation (US): ***explorers & producers*** **and** ***integrated*** **subsectors**

	dy_{it}	roe^+_{it}	roe^-_{it}	irr^+_{it}	irr^-_{it}	$market_{it}$	oil_{it}
				explorers & producers			
Const.	-0.007	2.155***	-0.487	0.001***	-0.001***	-0.001	0.011
	(0.677)	(0.007)	(0.653)	(0.000)	(0.000)	(0.740)	(0.222)
dy_{t-1}	0.970***	-0.445	-0.701	0.000	0.000***	0.004	-0.006
	(0.000)	(0.438)	(0.363)	(0.764)	(0.000)	(0.126)	(0.321)
roe^+_{t-1}	-0.001	0.785***	0.055	0.000	0.000***	0.000	0.000
	(0.492)	(0.000)	(0.240)	(0.742)	(0.001)	(0.709)	(0.647)
roe^-_{t-1}	0.001	0.021	0.735***	0.000*	0.000	0.000	0.000
	(0.355)	(0.453)	(0.000)	(0.080)	(0.563)	(0.933)	(0.149)
irr^+_{t-1}	4.273	-69.932	-334.479	0.397***	0.028	-0.318	-5.749*
	(0.503)	(0.807)	(0.383)	(0.000)	(0.537)	(0.825)	(0.072)
irr^-_{t-1}	-0.869	491.215	1028.482**	0.035	0.302***	-1.082	8.202**
	(0.906)	(0.137)	(0.020)	(0.529)	(0.000)	(0.515)	(0.026)
$market_{t-1}$	0.014	12.202	-1.688	-0.007***	-0.001	0.064	0.079
	(0.956)	(0.270)	(0.910)	(0.000)	(0.449)	(0.253)	(0.522)
oil_{t-1}	0.254**	-0.469	-2.186	-0.006***	-0.005***	-0.018	0.112*
	(0.026)	(0.927)	(0.750)	(0.000)	(0.000)	(0.493)	(0.050)
				integrated			
Const.	0.012	0.464***	-0.164	0.001***	-0.001***	-0.003	0.010
	(0.436)	(0.003)	(0.384)	(0.000)	(0.000)	(0.493)	(0.305)
dy_{t-1}	0.978***	-0.123	-0.006	0.000	0.000***	0.006**	-0.008
	(0.000)	(0.210)	(0.962)	(0.236)	(0.009)	(0.044)	(0.198)
roe^+_{t-1}	-0.006**	0.892***	0.022	0.000	0.000	0.000	0.000
	(0.013)	(0.000)	(0.472)	(0.714)	(0.157)	(0.618)	(0.913)
roe^-_{t-1}	0.002	0.029	0.903***	0.000	0.000	0.000	-0.003**
	(0.343)	(0.158)	(0.000)	(0.156)	(0.109)	(0.456)	(0.048)
irr^+_{t-1}	-3.898	-131.969**	-53.483 ***	0.382	0.037	0.040	-5.977*
	(0.445)	(0.011)	(0.395)	0.000	(0.433)	(0.978)	(0.064)
irr^-_{t-1}	-6.094	15.859	50.439	0.054	0.333***	-0.969	9.169**
	(0.289)	(0.785)	(0.476)	(0.332)	(0.000)	(0.554)	(0.012)
$market_{t-1}$	0.164	-1.023	3.853	-0.007***	-0.002	0.061	0.080
	(0.401)	(0.604)	(0.108)	(0.000)	(0.341)	(0.268)	(0.516)
oil_{t-1}	-0.029	-2.332**	-1.239	-0.006***	-0.005***	-0.015	0.101*
	(0.751)	(0.011)	(0.266)	(0.000)	(0.000)	(0.564)	(0.077)

Note: ***,**,* means significant at 1%, 5% and 1%, respectively. pvalues between parentheses.

Table C.7 reports the results of the Granger causality Wald tests for each equation of the underlying VAR model. The null hypothesis of the test is that the excluded variable does not

Granger-cause the equation variable. Note that each column, for instance, of Table C.3 represents one equation of VAR, and the same for the other countries. rer for the US is dropped because exchange rates are defined against the US dollar.

Table C.7
Granger-causality tests

Equation	Excluded variable	Test	pvalue	Test	pvalue
		explorers & producers		*integrated*	
		Canada			
dy					
	roe^{+}	0.463	0.496	0.491	0.483
	roe^{-}	0.038	0.845	1.063	0.302
	irr^{+}	0.326	0.568	3.786	0.052
	irr^{-}	5.516	0.019	0.988	0.320
	market	0.448	0.503	0.091	0.763
	oil	2.368	0.124	0.102	0.749
	rer	0.238	0.626	0.147	0.702
	ALL	8.752	0.271	6.146	0.523
		Japan			
dy					
	roe^{+}	2.591	0.107	0.013	0.909
	roe^{-}	0.009	0.925	0.092	0.761
	irr^{+}	3.892	0.049	2.388	0.122
	irr^{-}	0.336	0.562	3.616	0.057
	market	0.077	0.781	1.336	0.248
	oil	0.696	0.404	3.385	0.066
	rer	0.035	0.852	7.347	0.007
	ALL	7.456	0.383	16.172	0.024
		United Kingdom			
dy					
	roe^{+}	1.041	0.308	0.132	0.716
	roe^{-}	6.041	0.014	0.113	0.737
	irr^{+}	0.986	0.321	2.367	0.124
	irr^{-}	0.426	0.513	5.619	0.018
	market	0.003	0.956	0.043	0.835
	oil	0.098	0.754	4.173	0.041
	rer	0.212	0.645	0.241	0.623
	ALL	8.308	0.306	11.139	0.133
		United States			
dy					
	roe^{+}	0.472	0.492	6.189	0.013
	roe^{-}	0.855	0.355	0.899	0.343
	irr^{+}	0.449	0.503	0.583	0.445
	irr^{-}	0.014	0.513	1.126	0.289
	market	0.003	0.906	0.704	0.401
	oil	4.960	0.956	0.101	0.751
	ALL	6.132	0.409	9.507	0.147

Figure C.14 and Figure C.15 show the impulse response functions (IRF) for the variable dy. Note that the IRFs have no causal interpretation, yet they reflect the impact of a shock in one variable into another variable. The IRF confidence intervals are estimated using 1000 Monte Carlo draws from the distribution of the fitted reduced-form panel VAR model.

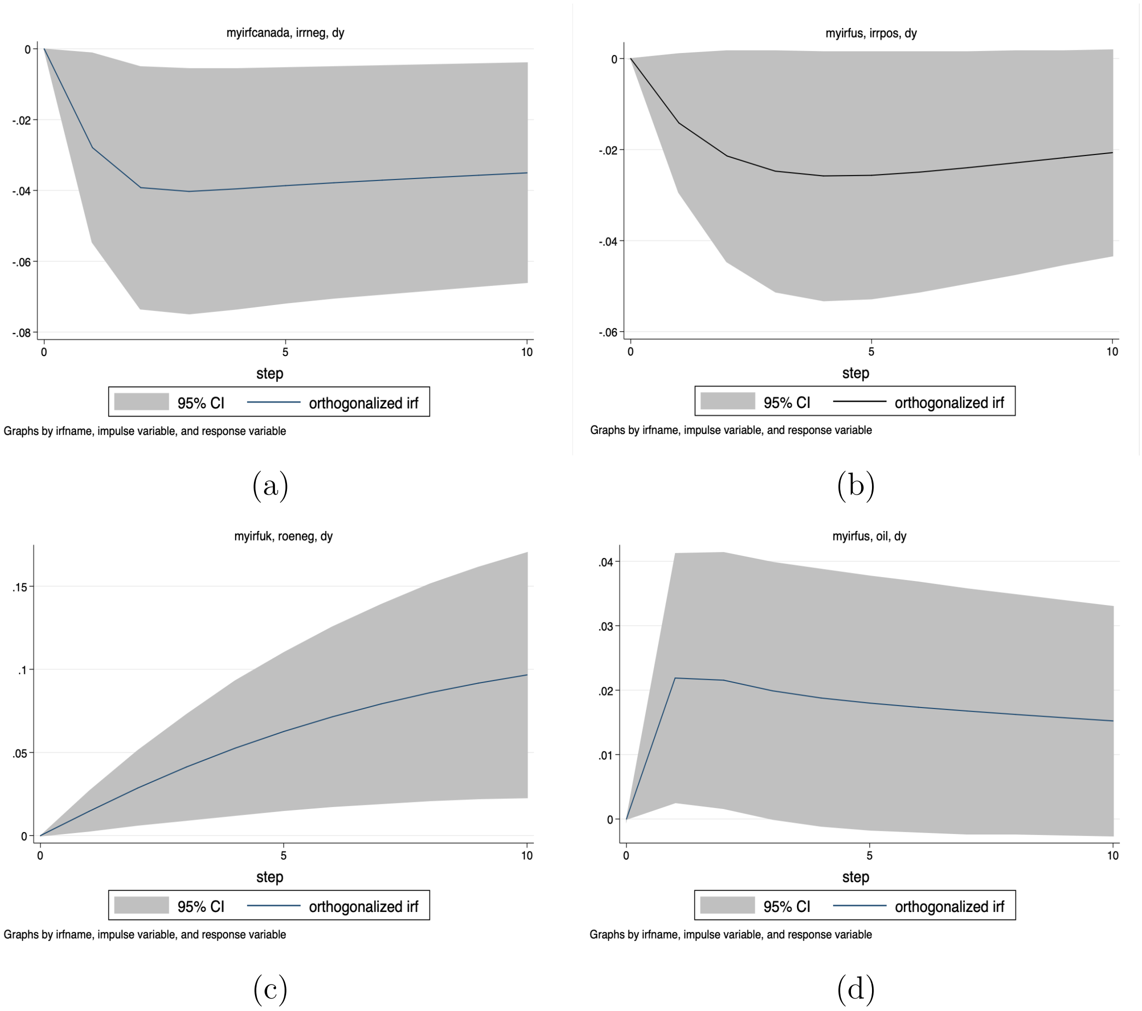
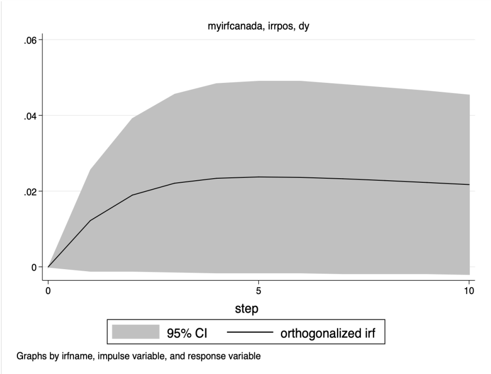
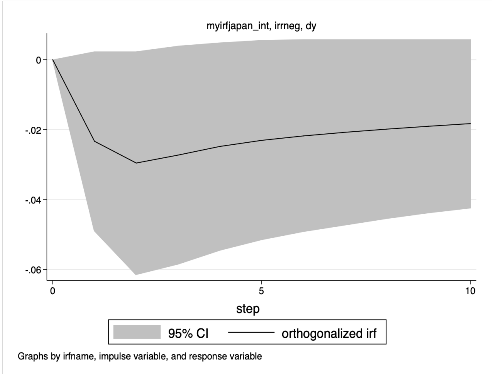


Figure C.14. Impulse response functions in the *explorers & producers* subsector. Response variable dy. (a) Canada (impulse: irr^-), (b) Japan (impulse: irr^+), (c) United Kingdom (impulse: roe^-) and (d) United States (impulse: oil).

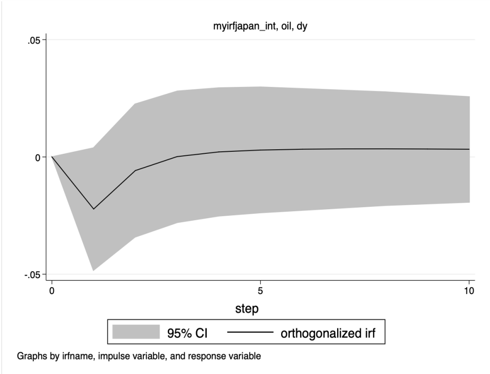
On the top of each graph the first variable corresponds to the variable impulse while the second corresponds to the variable response. The IRFs suggest that only dy in period $t-1$ has a significant impact on dy in both subsectors. For all the other impulse variables the confidence intervals include the zero line meaning that those impulses are not statistically significant.



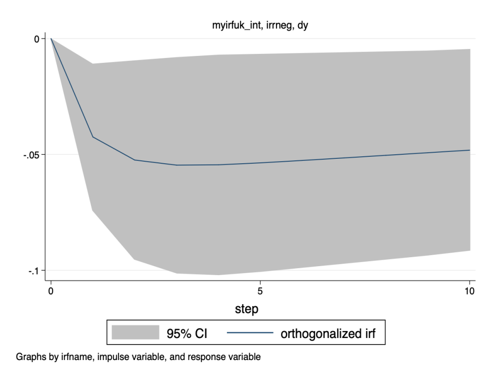
(a)



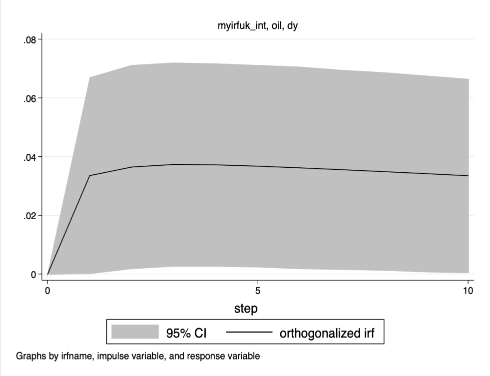
(b1)



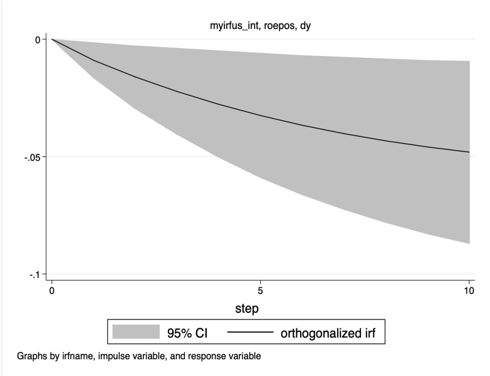
(b2)



(c1)



(c2)



(d)

Figure C.15: Impulse response functions in the *integrated* **subsector. Response variable** dy**. (a) Canada (impulse:** irr^{+}**), (b1, b2) Japan (impulses:** irr^{-}**,** oil**), (c1, c2) United Kingdom (impulses:** irr^{-}**,** oil**) and (d) United States (impulse:** roe^{+}**).**